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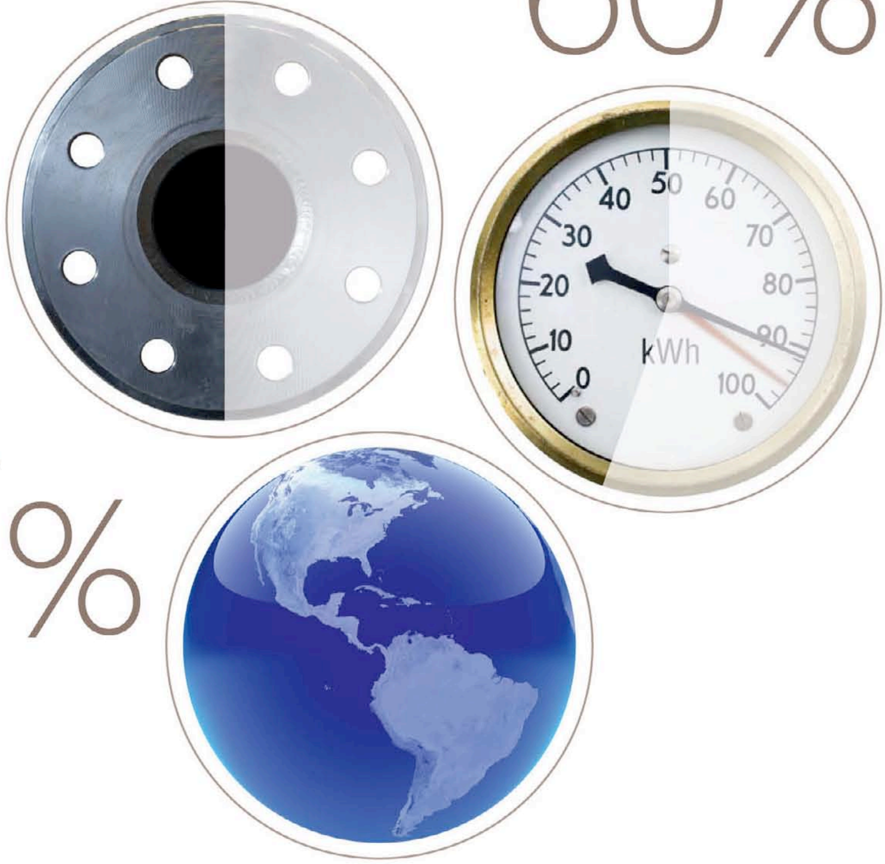


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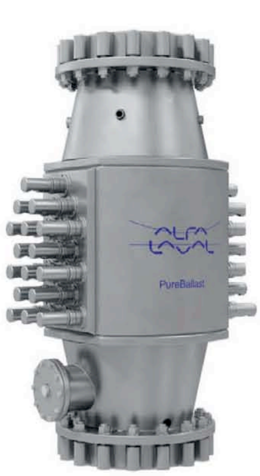

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7 A change of approach to safety could give the SOLAS regulations a shake up


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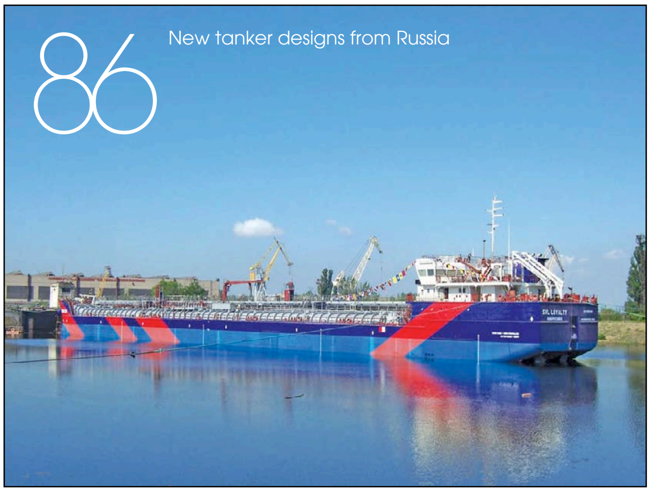

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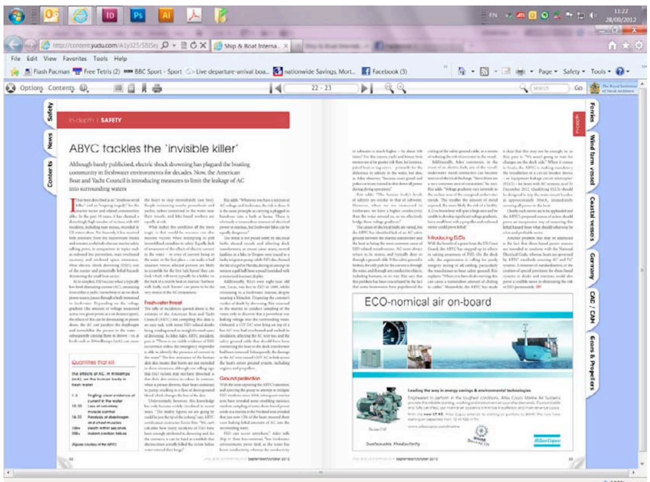



Photo courtesy of gcaptain

# Quantum of SOLAS

**Causes of the *Flaminia* fire remain uncertain, but new regulations will require a change of culture in the industry, say industry leaders**

Shipping has reached a moment that is rarely seen in any industry and it has been arrived at through the confluence of a number of occurrences, like astral bodies aligning in a solar eclipse.

In the first place the election of Koji Sekimizu to the post of secretary-general of the IMO has seen a shift in emphasis for the regulatory body; followed by the decision to merge DNV and Germanischer Lloyd, two major classification societies with senior figures who will be key to the development of class rules also signalling that they are interested in leading the industry to a brighter safer future; and finally the shift globally of wider societies to protect the environment and to significantly improve safety.

Initially the IMO secretary-general has initiated a debate within the industry that could well see the end of the 100 year-old SOLAS regulation. The mood at the IMO's Symposium was very supportive generally of Sekimizu, but with an understanding that the industry faced a great deal of work in order to improve its safety record further.

Tor Svensen of DNV, certainly a front-runner for a senior position in the newly merged DNV and GL, highlighted some of the difficulties that will need to be overcome. The industry will need to shift from a reactive to proactive regulatory system which will require a great deal of reporting from owners on the causes of accidents.

There is no doubt that societies across the world are becoming more aware of the dangers of shipping accidents, both environmentally and for health and safety reasons. With all the wisdom of an augury Svensen told the symposium that the industry could ill-afford another major accident.

Symposium attendees heard that as part of the new pro-active regulatory move the industry would need to change its culture. There would need to be openness on reporting incidents and an openness regarding any problems.

A matter of days later, as if to put the industry to the test, MOL suffered a major setback when one of its vessels, *MOL Comfort*, broke its back in the Indian Ocean.

The subsequent sinking of the aft end of the vessel with the loss of 1,700 containers means that many cargo owners will now be claiming for lost cargoes. This is a concern for the industry, as it raises some difficult questions; is there a design fault in mega-container ships? Was it an operational problem that caused the vessel to crack?

ClassNK has conducted a review of the documentation pertaining to *MOL Comfort* and it concluded: "The vessel design fully complied with all requirements of the ClassNK Rules and IACS regulations."

In addition the class society says the Special Survey of the vessel completed on 29 May 2013 "verified that no abnormalities were observed during the special survey and that the vessel was in full compliance with all requirements of the ClassNK Rules and IACS regulations at the time of survey completion."

If this is a worrying development for the industry as a whole the continued failure to either ascertain what is in a container and what its actual weight is, is a problem that has remained unresolved for some time.

The dangers of mis-declaring cargoes was ably demonstrated last year when the container ship *Flaminia* caught fire in the Atlantic after water in the hold appears to have come into contact with a chemical that it reacted with, believed to be calcium hypochlorite.

BIMCO wrote on its website this month: "Keeping tabs on those millions of containers and their contents is a problem familiar to the industry itself, which believes that not only is the true nature of the contents of many containers not known but, that their true weight is also unknown. These gaps in knowledge, the industry believes, compromise safety but filling the gaps is not proving easy."

Two people died in the explosion on *Flaminia*, it was a very serious accident and the vessel itself was feared to have more toxic chemicals onboard. Owners complained that it had to be towed back to Germany because ports in the UK, France and other countries on its route refused it entry.

It remains uncertain what caused the *Flaminia* disaster. While no-one died in the misfortune that befell *MOL Comfort*, it remains to be seen how much we learn from this incident.

If IMO believes that change is necessary for the good of the industry it will have to bring about a change in culture first in order for any new regulations to have a hope of being effective. And those changes will not be easy to realise. *NA*

Container Ships

## *MOL Comfort* reports eagerly awaited

Investigations into the causes for the structural failure of the stricken vessel *MOL Comfort* are expected to focus on operational factors rather than design errors, as the vessel met all the design rules, say industry experts.

Registered with ClassNK the vessel is said to have complied with all design requirements from both the class society and IACS. The vessel's last survey was completed and signed off on 29 May this year and again the class society says that the ship met all the regulations in place and that there were no "abnormalities" at the time of the survey.

The vessel broke its back while en route from Singapore last month with the two pieces subsequently floating apart and the stern section, carrying 1,700TEU sank on 27 June after taking on water and listing.

A fire on the front section has proved terminal and this part of the vessel also sank on 6 July with the loss of a further 2,400 containers. Engineers from, MOL, Lloyd's Register and ClassNK were hoping to get clues to the cause of the disaster from the front half of the vessel, but with this section now lost in water 3,000m deep this will be impossible.

In a statement ClassNK says: "In view of these unfortunate circumstances, the ClassNK Casualty Investigation Team will expedite the investigation into the cause of the incident, and expects to consolidate its preliminary findings by early September 2013."

MOL naval architect Yoshikazu Kawagoe said that the company had begun work inspecting *MOL Comfort's six sister ships, MOL Creation, MOL Charisma, MOL Celebration, MOL Courage, MOL Competence, MOL Commitment*. However, as a precautionary measure these ships will protect the vessel structure by taking operational precautions and MOL says: "We will conduct upgrade works to further strengthen the hull structure at the earliest timing. This will enhance the strength of the hull twice as much as the safety standards [require]".

LNG

## GTT continue SHI membrane talks

Philippe Berterotierre, the GTT president, has told *The Naval Architect* that discussions between the business partners regarding the design of Samsung's Smart Containment System (SCA) for transporting LNG are ongoing.

GK Kim, Samsung's chief marketing officer failed to provide assurances from the South Korean company that they would stop marketing the new membrane system which GTT views as a "poor copy of the Mk III" system.

Samsung believes that its system does not breach the intellectual property regulations and have vowed to continue marketing the SCA. More talks are expected between the two companies in the autumn.

Initial talks between the two companies started in 2011 when Samsung Heavy Industries (SHI) launched the SCA system which the French company, currently the only supplier of membrane technology, claims is a copy of its own design.

According to GTT, patents covering the design are expected to be released early this month, which Berterotierre hoped would end the dispute for the time-being. This may come as a blow to SHI who believed that the patents on the MK III had expired.

"The MK III is old technology, more than 30 years old, the patents will have expired 10 years ago," Kihun Joh, a principal engineer at SHI, said. Joh added that there is no agreement with GTT over the SCA technology because, "it is totally different technology," said Joh, adding that "We have invested our resources and money in R&D and we do not want to waste those resources".

SHI says that a number of owners, both Korean and foreign, are interested in the SCA system,which has now been upgraded so that the secondary barrier is allowed to move and this system, launched earlier this year in Houston USA is called the SCA W/S (welding & sliding).

"We have made the secondary barrier stress free," explained Joh. The secondary barrier in the upgraded SCA is not attached to the insulation so that as it shrinks under cooling and it does not damage the insulation or the welding.

Model casts using liquid nitrogen to cool the membrane have been used to test the design and the SCA W/S is set for type approval later this year, says Joh.

However, GTT is not impressed with SHI's latest development and Berterotierre is confident that the SCA W/S design is similar to a system that was developed in France, called the XX Membrane and the patents for this system will show that GTT own the intellectual property rights.

"The new version of SCA is a copy of GTT technology that we didn't introduce onto the market," Claims Berterotierre. "We tested a similar system in a cryogenic tank but we considered the system was too weak and so we discontinued the tests."

According to GTT the XX Membrane has around 60,000 moving parts and there is a "very high probability" that some will become trapped and will fail to move, if this happens pressure will be applied to the barrier, explained Berterotierre and "that may result with welding failures," he says.

He said that GTT and SHI would be in further talks about the SCA W/S this month and the patent should be available at the pre-arranged time from the patent office.

Meanwhile, GTT has developed a new system of its own. The MK V is a MK III derivative, but with no

bonding on the secondary layer, instead the invar will be automatically welded, make it easier to construct and it will have a boil off rate similar to that of GTT's MK III Flex system, of 0.1%, explained GTT commercial VP David Colson.

Effectively GTT are preparing for an upturn in demand for LNG and the MK V is aimed at smaller LNG carriers or fuel tanks. Larger ships will be able to use the MKV, but the system is a little higher priced than the MKIII Flex. Although, the MK V is similar to the SCA W/S in that it has reduced bonding requirements making it more attractive for operators in the Arctic.

SCA W/S is actively being promoted as a cold climate membrane system. "By minimising the bonding process we can achieve significantly shorter construction times and the quality control process is far easier, with fewer qualified staff needed," explained Joh.

SHI hopes to have sold its first SCA W/S by the end of this year and is in discussions with the Russian operators of the Yamal LNG field in the Arctic. According to SHI, construction of SCA W/S is well suited to the Arctic region because the bonding process is far harder in cold climates and the decreased bonding in the new system will mean it is easier to construct in the Arctic region.

Bidding for the Yamal concession started again this year, says SHI and the there is a possibility that some LNG tankers will be built in the Arctic region and the minimum bonding required by the SCA W/S means that is a real possibility.

Green Technology

# MOL tests SCR

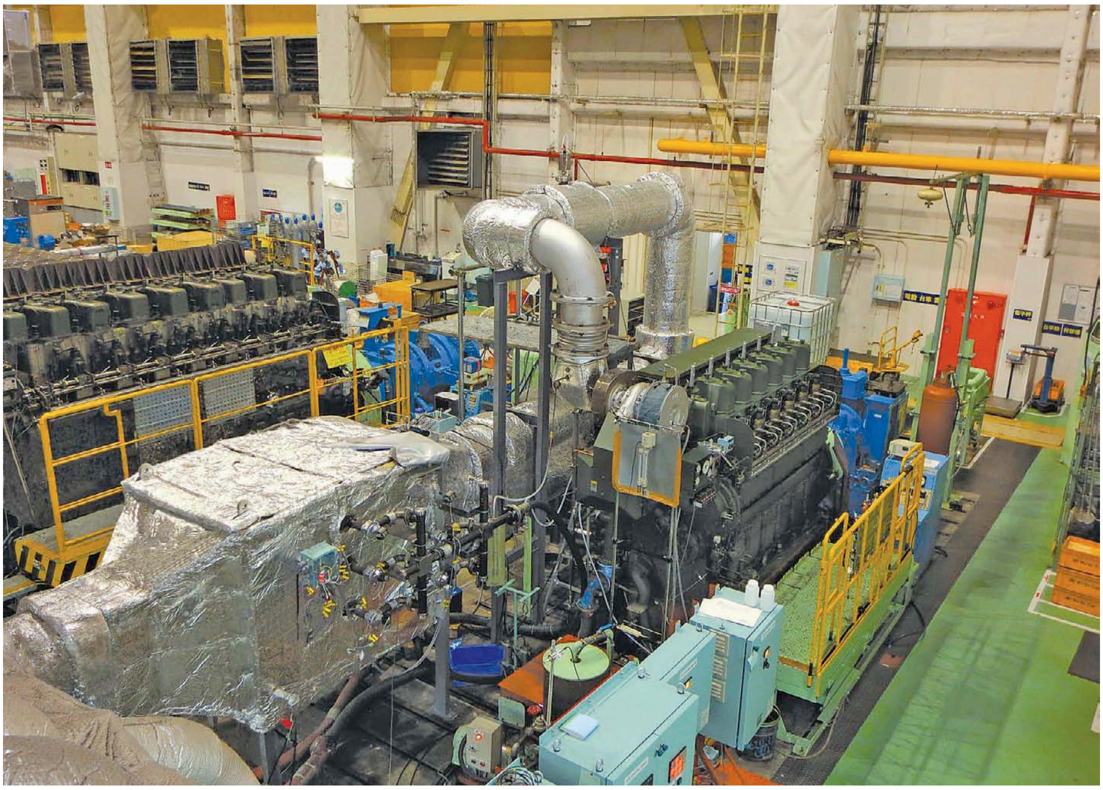
Japanese ship operator MOL has announced that it will be testing a selective catalytic reduction (SCR) system that it has developed jointly with engine manufacturer Yanmar and Namura Shipbuilding.

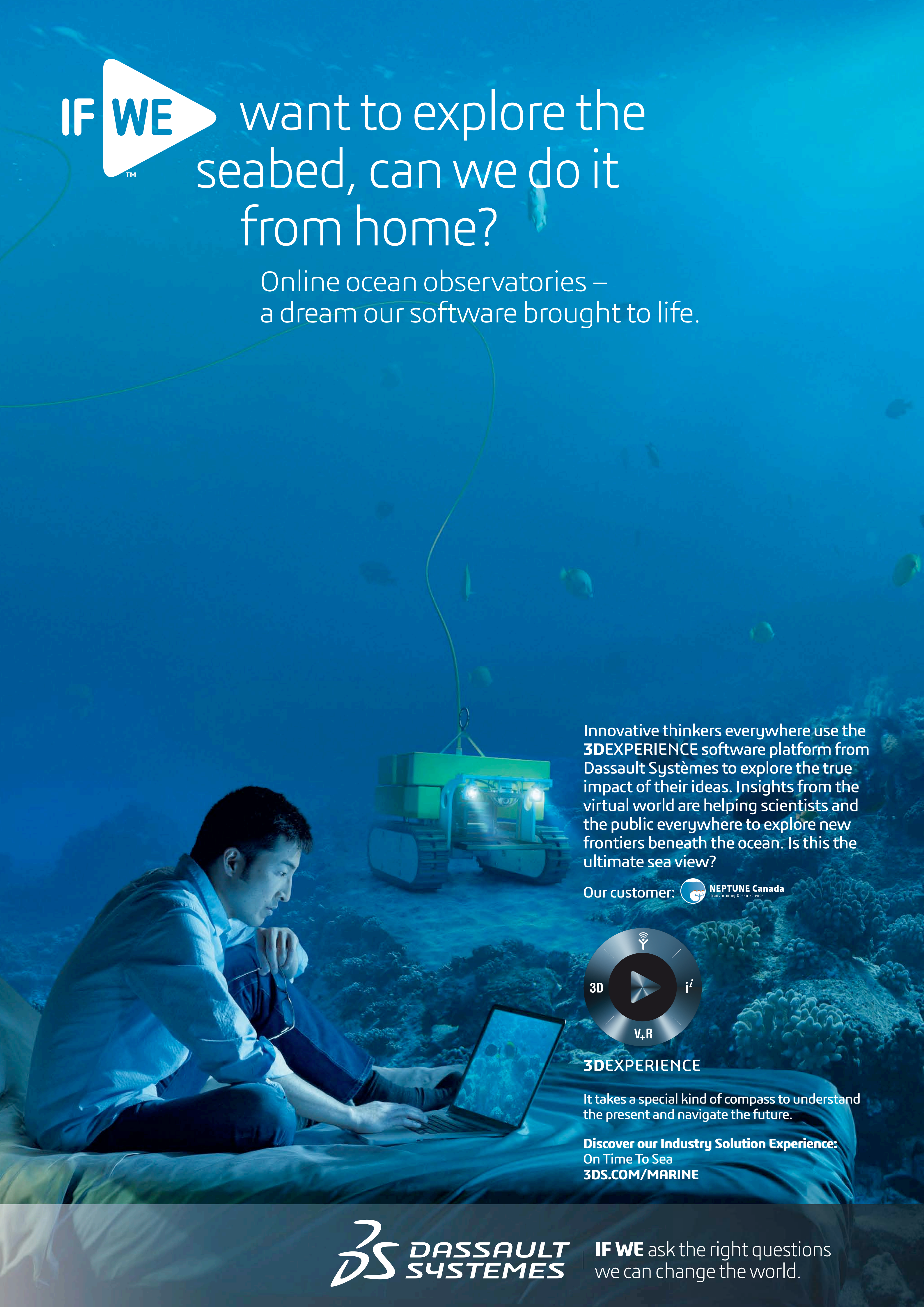
The SCR will be fitted to the power generators on a MOL vessel for demonstration purposes and it is expected to clean NOx from the exhaust gas sufficiently for the engines to meet IMO Tier III regulations. ClassNK has already approved the SCR system and states that it meets Tier III rules.

An outline of the system and the test proposals are as follows:

- Install a catalytic reactor that includes bypass system, onboard to save engine room space and allow greater flexibility in design
- Reduce space needed for peripheral equipment by integrating control of three units
- The test operation on an actual vessel is scheduled to last about two years, to observe operability and refilling of aqueous urea, and ensure that:
- All three SCR systems function properly under normal power generator operating conditions.
- Long-term performance of the system can be maintained even if the engines use Bunker C and other fuels that contain high levels of impurities. *NA*

SCR catalytic reactor onboard the vessel

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# Action stations

Debate at June's two-day symposium on ship safety instigated by IMO secretary-general Koji Sekimizu centred on the need to be pro-active as an industry rather than reactive.

According to Sekimizu the subject of the symposium "goes beyond simple compliance". He argued that as ships are becoming more complex so the regulations have also needed to follow. And SOLAS is an old regulation that is no longer fit for the modern industry.

Asked directly if he would like to replace SOLAS the secretary-general answered: "I see a lot of merit in that when touching upon the fundamentals, but we will have to wait and see what the MSC [the IMO's Maritime Safety Committee] decides."

In defining the issues for debate Sekimizu has effectively given structure to what should be an industry-wide discussion on maritime safety and the symposium may well prove to be a watershed in the history of maritime regulation.

"My aim was to raise issues for the maritime industry," he says and the discussion has leaned toward more Goal Based Standards (GBS) and more Risk Based Standards (RBS), but the over-riding idea was to "involve everybody in the decision making process".

Clearly some leading industry figures understood Sekimizu's aims and were readily onboard. Regulations, said DNV president Tor Svensen, were reactive, new regulations would evolve as a consequence of events, mainly accidents, such as *Titanic, Estonia* and *Herald of Free Enterprise*.

Wu Jiameng, vice-director, Merchant Ship Dept., Marine Design & Research Institute of China (CANSI) asked: "Are current rules and regulations too conservative?" In Jiameng's view some regulations are not explicit enough. "Scantlings are used as a proxy for the level of structural safety in the Harmonised Common Structural Rules [CSR-H] and this has led to an increase in steel weight," he pointed out.

According to Jiameng steel weight in bulk carriers and tankers increased by 5-8% as a result of the introduction of CSR; it will increase again as a consequence of moving from CSR to CSR-H. "Is this necessary?" he asks.

"CSR-H will be in compliance with the IMO GBS which will increase steel weight comparing to current CSR. Such increase will impact the deadweight and EEDI. It should be considered not only by the designers and Class, but also by IMO when developing such codes or standards," says Jiameng.

In addition Jiameng pointed out that some rules and regulations may produce contradictory results. For example the EEDI requires less power and that may compromise safety in some instances.

Koji Sekimizu wants to move to proactive regulation

Rules for the design of tankers and bulk carriers are "prescriptive", argued Jiameng, but he added that for other ship designs GBS could be preferable, but only if an equivalent level of safety could be attained.

Guidelines for the development of such rules must be drawn up by the regulating bodies, tests need to be carried out and onboard monitoring systems need to be established in order to verify that the new rules can offer an acceptable level of safety.

Jiameng argued that the industry should draw up plans to move to a better type of regulation, but that these plans should harmonise the needs of industry and society and should offer the maritime industry a "soft landing" period for industry to complete a review of the regulatory needs.

Svensen apparently endorsed Jiameng's view, but added that: "Shipping has been a facilitator of global trade as it has expanded, while containerisation has been the biggest innovation for global trade anywhere," and he concluded that "regulation must embrace technology and trade and not hinder them".

He told the packed audience in IMO's main hall that shipping "operated in a global landscape and it was a complex world with no tolerance of failure". According to Svensen the "new risk reality" for owners was that live pictures of any event virtually anywhere in the world could be seen even before emergency services had time to respond. "The maritime industry cannot afford another major accident," he said.

That said the unexplained accident suffered by *MOL Comfort* is another blow to the safety record of the industry, even though there were no fatalities the accident raises questions over the safety of super post-Panamax containerships. This is particularly poignant given the delivery this month of the first Triple E vessel and China Shipping's order for 18,400TEU ships.

In the previous week to the IMO Symposium, Svensen had told assembled journalists at the Nor-Shipping event that the newly merged DNV and

Tor Svensen wants to lead industry debate on safety

Germanischer Lloyd (GL), which will have a market share of around 24%, will seek to lead the industry debate on maritime safety.

"We will set the agenda for class and safety is the number one objective," said Svensen. He added that DNV GL will: "develop and address the areas important for the industry - in particular fewer serious accidents".

Svensen argued that the safety trends within the maritime industry were not improving and that in spite of

Regulations are not explicit in some cases, says Win Jiameng

a raft of new technologies such as ECDIS and GPS navigational errors still accounted for around 50% of maritime accidents. "The offshore industry is more advanced in risk management," he added.

According to DNV, the industry must identify high risk areas and develop a safety barrier approach to prevent accidents. "In addition we must focus on rules to fill any gaps in regulations and survey procedures; the aim is to drive the industry forward to better safety".

Svensen believes that class will play a strong role in enforcing regulations, though he stopped short of arguing for a policing role for class. "Class needs to play a stronger role, but in partnership with industry," he said.

With that in mind Svensen concluded his IMO symposium address by calling for a new overarching convention that would cover SOLAS, MARPOL and the Load Line Convention that will "remove any gaps and embrace technological developments".

These new Goal Based Regulations should be effective, attainable, predictable, transparent, reproducible and relevant, he says, adding that less detailed rules can be developed more quickly and can prevent the need for regional variations.

Instead class should develop detailed rules that are supplemented with industry standards and these rules should be justifiable through a process of evaluation that uses a risk based approach and will include the use of rule impact assessments.

Development of all these rules will, however, be dependent on the accurate reporting of all accidents by the ship operating companies and this could prove to be the weak link in the new regulatory chain.

Former Lloyd's Register marine technical director Vaughn Pomeroy accepted that reporting of accidents from shipping lines may prove problematic. Ship operators may not be keen to report accidents which may have insurance claims attached and/or legal repercussions.

Nevertheless, the reporting element of the RBS is crucial as RINA's Jim Peachey and Rae McIntosh, in the symposium's only joint presentation, explained. Peachey outlined the process for a proactive safety system.

Initially companies will need to make a Formal Safety Assessment (FSA) that will identify hazards and the root causes of events. By identifying possible hazards operators can proactively set methods for preventing accidents.

Implicit in this method is the requirement to learn from any events and to adjust rules and regulations as a consequence of those events that will offer operators a safety system with risks that are As Low As Reasonably Possible (ALARP).

According to Peachey the maritime industry can learn from the safety systems developed in other industries, including nuclear, aviation, the railways, the offshore oil and gas industry and the chemical industry, which all use the risk based approach to safety. *NA*

Lifesaving & ship safety

## It's a gas for Autronica

Autronica Fire and Security AS has launched its next generation gas safety system for liquid and chemical tankers. The new AutroSafe Maritime Gas Panel Solution introduces a number of key new features that support more flexible installation, improved maintenance and troubleshooting in addition to more reliable, accurate and user-friendly data from Autronica and third party sensors, the company noted.

The system has been designed to meet all current regulations for gas detection systems and features AutroNet, an Ethernet-based panel network that connects all panels and sensors through a dual-path, high-speed (100Mbps) redundant system.

The AutroSafe Maritime Gas Panel Solution alarm control panel use a communication loop called AutroFieldBus (AFB) to communicate with the gas detection loops, called PowerLoops.

**www.autronica.com**

Ancillary equipment

## Under pressure

Leser has expanded its range with its pilot operated safety valve (POSV) for pressures from 102 up to 3,705psig / 256bar. The valve which has been developed for land-based industry, will also be beneficial to the maritime industry the company says.

"Size and weight are key features for safety valves in maritime and offshore operations", says Mirko Engel, managing director of Sales at LESER. "For our pilot operated safety valves, including the new valve for high pressures up to 256bar, we considered the latest design and technology experience. The result: a small and light POSV with an integrated tubing well protected against external damage. Surely we optimised also our supply chain for this product, which makes it available with an outstandingly fast delivery time of four weeks ex works."

**www.leser.com**

Ancillary equipment

## Post-Panamax contracts for TTS

TTS Marine AB has signed two new contracts in South Korea with a total value of approximately NOK150 million (US$26 million).

One of the contracts is with Hyundai Samho Heavy Industries shipyard and the other is with Hyundai Mipo Dockyards. Both contracts are for the delivery of technology and equipment to a total of six post-Panamax car carriers to be built over the next two years.

The contract will see TTS supply its car deck design, stern ramps and technological solutions that it has said will greatly increase the efficiency of the next generation of car carriers. The available deck area on the vessels has been expanded by 5-10%, and the ships will be built lower than before to allow them to run more efficiently. The equipment is due to be delivered during 2014.

**www.tts-group.com**

Navigation

## Fugro gets onboard with CMA CGM

Fugro Seastar AS has fitted *CMA CGM Marco Polo* with its Marinestar manoeuvring system to assist the vessel in berthing and navigation. The satellite aided navigation technology is based on composite GPS and Global Navigation Satellite System (GLONASS) constellations and measures the speeds at the bow and the stern, together with quay distances to assist the vessel safely to the berth. The Marinestar system will provide speed and heading information to a higher level of accuracy than conventional navigational aids such as doppler log and gyro compass, according to the company.

In addition to its navigation and berthing functions, Marinestar Manoeuvring System will be able to measure a vessel's fore and aft trim dynamically whilst underway at sea. In addition to the 16,000TEU *CMA CGM Marco Polo* and the two sister vessels *CMA CGM Jules Verne* and *CMA CGM Alexander von Humbolt*, the system will also be installed on five other 13,800TEU vessels in the CMA CGM fleet.

**www.fugro.com**

CAD/CAM

## Wan Hai Lines goes green

Taiwan-based Wan Hai Lines has opted to use the ClassNK-NAPA GREEN ship efficiency software on its WAN HAI 516, a 4,680TEU vessel delivered by CSBC in April 2013. This is the first time that the operational optimisation and SEEMP (Ship Energy Efficiency Management Plan) solution will be installed commercially on an existing vessel, noted the class society.

The ClassNK-NAPA GREEN system is a comprehensive software system developed by NAPA and ClassNK to help owners and operators reduce fuel costs and $CO_2$ emissions and comply with the IMO SEEMP requirements, which entered into force at the beginning of 2013.

**www.classnk.org.jp**


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CAD/CAM

## Dassault Systèmes launches My.SolidWorks

Dassault Systèmes has launched its My.SolidWorks, a free online community site that will provide access to any SolidWorks content.

My.SolidWorks will provide users with a consolidated view of the latest updates from around the SolidWorks community. The site will feature the latest blogs, discussions and videos, which can be filtered based on a users' individual needs and interests.

It will also allow users to search the entire SolidWorks community at once, along with the ability to share what they find with colleagues, peers and friends with the social capabilities built into My.SolidWorks.

**www.3ds.com**

CAD/CAM

## Herbert-ABS lightens the load

Herbert-ABS Software Solutions LLC has released its latest version of CargoMax Load Management Program for ships.

CargoMax is type approved by major classification societies and aims to maximise cargo utilisation, simplify regulatory compliance, monitor margins of safety during cargo operations and improve safety by reducing human error, says the company.

The newly released CargoMax 2.1 includes calculation enhancements for load discharge rate monitoring, advanced load/discharge/ballast water exchange sequencing and advanced bulk pile features. Additionally, a fully rendered 3-D graphical display shows tank and cargo fillings, vessel attitude and is fully interactive with pan, zoom, rotate and customisable cutting planes. A trim optimisation tool also has been added and is fully integrated into CargoMax 2.1.

CargoMax is available for use onboard tankers, bulkers, ro-ro ships, containerships, barges and other vessel types.

**www.herbertsoftware.com**

Ancillary equipment

## Holmatro gets multi-tasking

Holmatro has upgraded its multi-purpose cylinder range. The launch of its latest range offers a broad choice of solutions for varied industrial tasks. Holmatro aims to provide more for its customers through a more expansive range of multi-purpose cylinders often used in lifting equipment at shipyards. Customers can now choose from 50 different models that are fitted with base mounting holes and collar thread as standard. The models with a capacity of up to 50tonnes also have an internal plunger thread.

Holmatro extends its cylinder range

The multi-purpose cylinders have been developed with the latest technology to make them more corrosion resistant and stronger than other cylinders.

**www.holmatro.com**

Navigation

## Kongsberg gets connected

Kongsberg Maritime has introduced its latest utilisation of an Ethernet based LAN (Local Area Network) to Kongsberg Maritime's K-Bridge Integrated Bridge System, which is capable of improving safety and navigation through enhanced radar functionality, whilst offering installation benefits, noted the company. The system is currently undergoing type approval testing at DNV, with the first customer delivery expected in Autumn 2013.

The new radar topology will provide enhancements in how radar data is presented, with improved signal processing and automatic radar and picture tuning. Images from several radar antennas will be viewable on the same screen including the possibility to view both X-band and S-band data in the same image. By presenting a picture compiled in real-time from several radar antennas, the operator will have a detailed picture that displays seamless tracking of up to 1,000 targets in a full 360degs view, noted the company.

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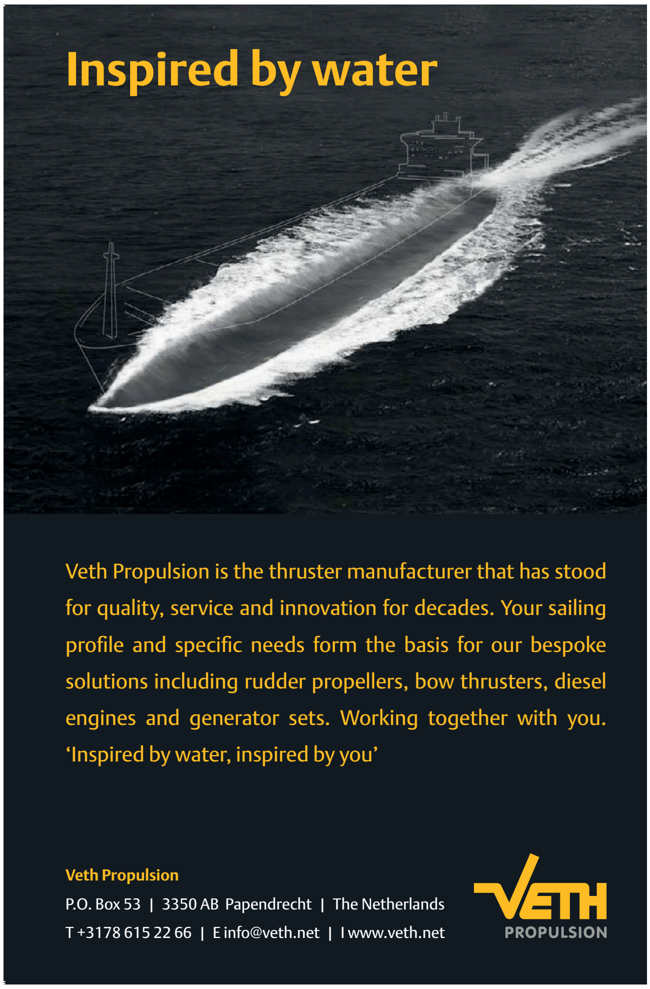
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Ancillary equipment

## Rolling orders for MacGregor

MacGregor, part of Cargotec, has secured orders worth around €10 million (US$13.2 million) to deliver comprehensive ro-ro cargo access equipment for four 6,700 unit pure car/truck carriers (PCTCs) to be built in China. The order for two of the vessels was received from Samjin Shipbuilding and the order for the other two was received from Jinling shipyard. The internal ramps for the vessels to be built at Jinling shipyard will be electrically-operated.
**www.cargotec.com**

Propulsion

## Rolls-Royce gets the thrust

Propulsion manufacturer Rolls-Royce has signed an extensive equipment order with the Italian shipbuilder Fincantieri Cantieri Navali Italiani S.p.A for shipowner Viking Cruises, with a total value of approximately £3 million (US$4.5 million) to Rolls-Royce.

Viking Cruises recently ordered two cruise ships from Fincantieri and has opted for the Rolls-Royce integrated rudder and propulsion system Promas, for their vessels.

In addition to the Promas propulsion system, Rolls-Royce will deliver deck machinery and steering gear for the Viking Cruises vessels. The vessels are due for delivery in 2015 and 2016.

Furthermore, Rolls-Royce has won a contract to supply its Promas propulsion system for two new car and truck carrying ships which are being built in Korea for Neptune Lines.

The vessels will be built by Hyundai Mipo Dockyard Co (HMD) and will also feature steering gear and deck machinery from Rolls-Royce.

HMD has also signed an agreement with Rolls-Royce for further model testing of its Promas system in order to evaluate its suitability for a number of other vessel designs. HMD will instruct an independent tank test institute in Korea to conduct the tests, where competing energy saving systems will also be evaluated.
**www.rolls-royce.com**

Lifesaving & ship safety

## Drew Marine sends out its signal

Drew Marine Signal & Safety which manufactures marine distress signals has launched its new Comet Light and Smoke Signal and Pains Wessex Manoverboard MK9. The product features individual LED light pods for quick installation and testing, the product also has a new retaining clip to prevent accidental deployment in rough seas. Its single-piece stainless steel bracket allows it to fit existing installations. These markers are mounted on each bridge-wing attached to a 4kg lifebuoy.
**www.drew-marine.com**

Drew Marine launches latest safety product

# IMO resolves ro-ro rules puzzle

IMO reiterated its position on necessary Energy Efficiency Design Index (EEDI)-fixes for the ro-ro ship segments (ro-ro cargo, ro-ro passenger and vehicle carriers respectively). Swedish naval architect and member of the Swedish proposal team Jan Bergholtz explains how the new regulation will affect future ro-ro shipping

Following the deliberations and decisions made during MEPC 65, the scope of the EEDI has been extended to now also include passenger ships with non-conventional propulsion, i.e. cruise ships, ro-ro vehicle carriers, ro-ro cargo and ro-ro passenger ships.

While widening the EEDI-regime the IMO has begun to acknowledge that "one shoe does not always fit all". Accordingly, the marine environment protection committee agreed to accept different approaches for the development of reference lines and for some ship segments also ship type specific correction factors for the application of the attained EEDI.

In addition, the application of adequate correction factors intended to establish normalised and comparable condition for the smaller sized general cargo ships, as proposed by The Netherlands, were accepted. Moreover, the committee acknowledged that cargo ships having an ice-breaking capability, i.e. ships designed to independently break 1.0m thick level ice or more (in principle PC1, PC2 and PC3 Polar Code classed ships), should be exempted from the EEDI-requirements.

The proposed amendments of the new chapter 4 in MARPOL Annex VI are anticipated to be adopted during MEPC 66 in April 2014 and entry into force can be expected 18 months later. Consequently, only "passenger ships other than cruise passenger ships" remain outside the EEDI regulatory framework, in terms of reference lines and reduction factors.

With regard to ro-ro cargo and ro-ro passenger ship types the committee echoed the decision made during MEPC 64, to finalise the EEDI methodology based upon the proposal as presented by Sweden, Germany and CESA and as supported by Interferry. Hence, the Swedish led contingent convinced the committee that, for these rather diverse ship types, some means of taking the physics into account is needed in order to provide a fair basis for comparison.

In widening the EEDI regime the IMO acknowledges that "one shoe does not fit all" says Jan Bergholtz

The background and rationale to the Swedish proposal can be explained as follows; the EEDI-reference lines are developed applying a regression analysis on statistical fleet data of existing ships. In principle, a fair and robust EEDI reference line should be derived in such a way that this line can be considered to constitute the best possible average performance of the fleet represented by statistical data. This implies that all data sets should fall as close to the regression curve, the EEDI reference line, as possible, rendering a high correlation and low standard deviation while safeguarding that acknowledged efficient ships exhibit a lower EEDI-value than comparable "bad performers".

The original concept in which the non-normalised EEDI is expressed as a function of the capacity, normally dwt, may suit its purpose for homogenously composed fleets, e.g. ships engaged in transoceanic deep sea shipping, for which the spread in EEDI for ships of a certain size in terms of dwt is relatively limited and normalisation of physics such as the influence of Froude's number may be disregarded without significantly affecting the fleet average - the physics are to some degree captured in the capacity.

However, also for homogenously composed ship types the EEDI-scatter increases with decreasing size. For the smaller ship sizes, i.e. ships normally engaged in short sea shipping, noticeable predicaments in the robustness of the EEDI-methodology have been recognised and acknowledged. The IMO-cure to the scatter problem has so far included a so called lower-size threshold below which, the EEDI reduction requirements do not apply and moreover a size range within which an interpolated implementation of the required EEDI is applied.

As the ro-ro cargo and ro-ro passenger ship types are in full "true" short sea shipping segments characterised by a significant diversity in mission profile, the introduction of lower-size thresholds cannot offer the needed "fix". Hence, an enhanced robustness of the EEDI-methodology calls for the inclusion of some elements to take into account the pronounced variety in operational conditions and geometrical constraints governing the energy efficiency from a design perspective for these ship types.

In principle the Swedish concept applies a correction factor based upon ship specific design parameters aiming to normalise the numerator of the EEDI-equation, i.e. the $CO_2$-burden, to comparable conditions. The correction factor includes the Froude's number, resulting in a third order speed power relation, and moreover non-dimensional geometric ratios all of which are acknowledged to influence the hydrodynamic performance and hence the energy consumption of a ship.

In addition the Dutch study on necessary EEDI corrections to be applied on general cargo ships concluded that in order to establish comparable conditions for this ship type, in addition to factors derived to take into account the influence of various types of cargo handling gear and voluntary structural enhancements, introduction of a power correction factor including a Froude number element and the block coefficient would be required.

The application of a cubic Froude number - power relation has also been found a necessity when tweaking the EEDI-reference line for ro-ro vehicle carriers as proposed by Japan, Denmark and Norway, in order to exhibit a more acceptable regression line curve fit.

"speed reduction does not turn a poor design into a good performer"

Nevertheless, during MEPC 65 the Danish led opposition expressed their concerns, claiming that the inclusion of a cubic Froude number was clearly violating the principles of the EEDI by reducing or even eliminating the influence of speed. In response the Swedish led consortium explained that the objective of the methodology is neither to penalise nor to reward speed, but to address the gradient of the performance curve. In our vieww a speed reduction does not turn a poor design into a good performer. However, as the correction factor addresses the gradient of the performance curve and hence also directly the energy consumption for a specific transport work, the method will provide a stringent instrument for enhanced energy efficiency.

Accordingly the objective of our proposals has been to derive an instrument in which the same physical conditions that governs the performance of a new ship design are to the furthest extent also taken into consideration when developing the reference lines, i.e. the EEDI requirement; the left-hand side of the equation should match the right-hand side.

$$EEDI_{Attained} \geq EEDI_{Required}$$

Obviously new designs must perform initially equal to and eventually better than fleet average for the time of implementation. However, since both the development of the EEDI reference lines as well as the calculation of the attained

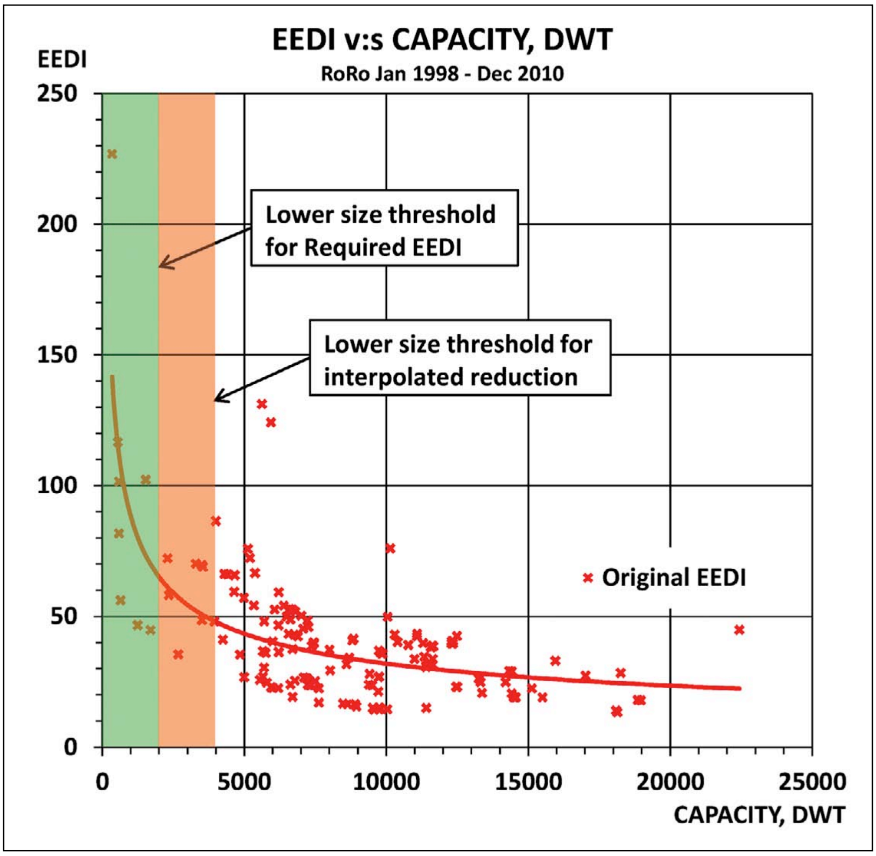



Figure 1: Illustration of the IMO-cure to EEDI reference line scatter problems

EEDI of a new design are based on normalised comparable conditions the robustness is significantly increased. In our view without the normalisation a statistical fleet average is meaningless and may lead to the disqualification of energy efficient ships for which no sea-borne alternative can be found.

Another concern raised by the Danes was that the Swedish proposal would be unfair because it would benefit ro-ro ships enormously, compared to all other ships. The reasoning behind this statement is, in the view of the Swedish led contingent, quite difficult to grasp since the explicit intention of the EEDI-concept as such is to facilitate the comparison only between ships which can undertake each other's transport work, i.e. ships within the same ship type. Moreover, it needs to be remembered that the ro-ro cargo and ro-ro passenger ship fleets are merely competing with land based transportation modes.

So what will the agreed ro-ro cargo and ro-ro passenger ships concepts impose on future ro-ro ship designs? According to the Swedes; as could be expected by any energy efficiency enhancement instrument, improved propulsion performance and hence a lesser gradient of the speed-power performance curve is of course one key-parameter to a successful EEDI-reduction. Some critical voices have stated that the instrument may be too stringent, thereby not allowing for speed reduction as an alternative means for reducing the attained EEDI, sometimes referred to as the low-tech solution. Yet, the Swedish consortium, maintain the position that reducing speed does not turn a poor design into a good performer. In the study completed by the Swedes we have come to the conclusion that 12% of the ro-ro cargo ships hourly generate 25% of the fleet $CO_2$-emissions per shifted deadweight tonne. It is primarily mitigation of such designs the instrument is aiming for.

Moreover, in many cases the trades which are governed by timetables do not allow for significant reductions in transport frequencies, particularly when passengers are involved. Hence, any consequent assessment of a speed reduction must, for at least the ro-ro passenger fleet, include the evaluation of a plausible modal shift.

Indeed, given the limited number of main particulars at hand a perfect energy efficiency enhancement instrument cannot be developed. The aphorism "one shoe does not always fit all" becomes increasingly evident as the diversity surges. However, by the introduction of the ship design variable some means for taking operational conditions and geometrical constraints into account is granted. In addition as for all other ship types, the use of alternative more GHG-neutral fuel types and the application of future innovative technology will of course also contribute to a reduced attained EEDI.

Nevertheless, since the methodology was first conceptually presented at the second intersessional meeting of the working group on energy efficiency measures for ships, EE-WG 2 in January 2012, the Swedish/German concept has, in close cooperation with the Technical University of Hamburg-Harburg (TUHH), Community of European Shipyard's Association (CESA) and Interferry, been comprehensively assessed by experts in the academia, shipbuilders well renowned for their ability to design and construct state-of-the-art energy efficient ro-ro ships as well as ro-ro ship owners and operators. All parties have been able to acknowledge the individual ranking and margin towards the fleets' average in terms of the derived reference line for the ro-ro cargo and ro-ro passenger ship's respectively.

At the same time the assessments have also confirmed that the best performers, operating today and recognised as versatile designs, already meet the requirements of tomorrow. The inclusion of the ship specific design elements in the correction factor is, according to our understanding, the only possible solution to allow for a continued diversity of the ro-ro cargo and ro-ro passenger ship fleets, providing an energy efficient service to the benefit of the society in many cases as an alternative to less efficient land based alternatives. *NA*

# Dutch solution for general cargo ships' EEDI

Dutch-based Conoship and tank test institute MARIN have been evaluating how the Energy Efficiency Design Index (EEDI) will impact the general cargo market. Jan Jaap Nieuwenhuis, manager design department, Wieger Duursema, naval architect, Conoship International and Michiel Verhulst, senior project manager ships, MARIN, explain further

In its pursuit of reducing pollution caused by shipping, IMO instigated new measures to improve the energy efficiency of ships and ultimately to reduce $CO_2$ emissions. These measures became mandatory through the adoption of amendments to MARPOL Annex VI during the 62nd session of the Marine Environment Protection Committee (MEPC). The new regulations came into force from the 1 January 2013. The key instrument to reduce $CO_2$ emissions from ships is the EEDI. This index, which is mandatory for new ships or ships which underwent a major conversion, is calculated by dividing emissions through the benefit to society, which is expressed as "transport capacity" times "ship speed" of the vessel.

In the process up to MEPC 62, and also after this meeting, the Dutch delegation indicated that a significant segment of the general cargo ship fleet would encounter problems in meeting these requirements. For a number of these ships this is not in conflict with the purpose of the index: these ships simply have too low energy efficiency and need to be improved. However, it was shown by Anink and Krikke (2011) that for many of the general cargo ships the high attained EEDI value originates from specific design elements which are required because of their operational profile and not a sign of low energy efficiency. Further, the values of attained EEDI for general cargo vessels show a lot of variance.

From 31 December 2011 over 67% of the Dutch fleet of ships above 100GT is a general cargo ship, see Vlootboek (2012). A fair inclusion of general cargo ships in the EEDI regulatory framework is therefore important for the Dutch flag. In 2011, a consortium was formed consisting of the Dutch flag state, the Holland Shipbuilding Association, the Royal Association of Netherlands Shipowners and the Ministry of Infrastructure and the Environment, which initiated a research project to find the main causes of the large differences between attained EEDI values of general cargo ships with about equal deadweight. A further objective of this research project was to propose measures to improve the inclusion of general cargo ships in the EEDI regulatory framework.

## EEDI framework

There are two ship specific indexes that define whether a ship does or does not comply with the EEDI regulations. The first is the attained EEDI, which is an index defined for each ship and mainly determined on the basis of the parameters deadweight, power and speed. The second is the Required EEDI value, an index which is solely determined on the basis of the deadweight. The attained EEDI value should be lower than the required EEDI obtained from a reference line, which will be lowered over time in three phases. The reference lines are based on attained EEDI values calculated for a large number of ships of which the data was obtained from the IHS Fairplay database. The following table shows the number of ships used for determination of the ship type specific reference lines and the resulting R2 value, which is a statistical measure for how well the data fits the regression form. As can be seen in the table below, the R2 of General cargo ships is low compared to other ship types, which means the scatter of attained EEDI values around the reference line is large. Because of the difficulties with the derivation of a robust reference line, small general cargo ships up to 15,000dwt were excluded from the first phase of the EEDI requirements. However, from January 2015 general cargo ships of between 3,000dwt and 15,000dwt will also have to meet the EEDI requirements.

It was shown by Anink and Krikke (2011) that for a significant number of the general cargo ships the high attained EEDI values is not a result of low energy efficiency, but is a result of the differences between general cargo ship designs regarding specific design elements and operational profiles to meet specific market demands. Indexing the energy efficiency of general cargo ships solely on the basis of speed, power and deadweight clearly results in an unfair comparison of these ships. Therefore, in order to achieve a fairer inclusion of general cargo ships in the EEDI regulatory framework the specific design elements and operational profile aspects, which cause a high scatter, should be identified first.

## Causes of high scatter

To identify the main design elements which cause the scatter for a large part, a systematic assessment of the attained EEDI values of a group of ships was conducted, as well as an investigation of the design details/aspects. Therefore, a purpose-built database was created. Over 40 characteristics of more than 70 ships were gathered in the database, including main dimensions, lightweight, weight of loading equipment, estimated weight increase related to additional class notations and speed to power data.

The ships in the database are Conoship designs and/or ships which are extensively tested and optimised by MARIN and general cargo ships built or owned by

| Ship type | R2 | Population |
|---|---|---|
| Bulk carrier | 0.9289 | 2512 |
| Gas tanker | 0.9446 | 354 |
| Tanker | 0.9574 | 3655 |
| Container ship | 0.6191 | 2406 |
| General cargo ship | 0.3344 | 2086 |
| Refrigerated cargo carrier | 0.5130 | 61 |
| Combination carrier | 0.9575 | 6 |

Table 1: R2 and population of vessels used for determination of the reference lines

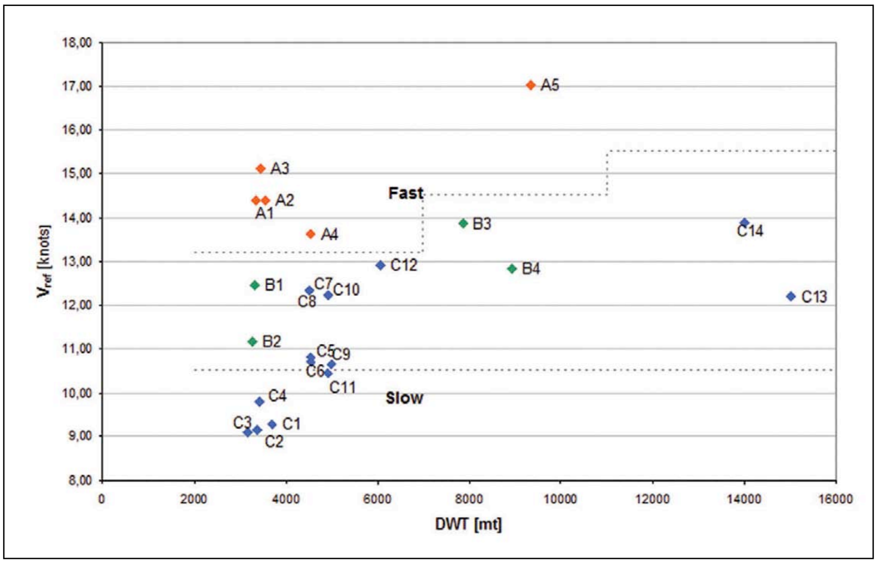



Figure 1: Reference speed (knots) versus deadweight (mt)

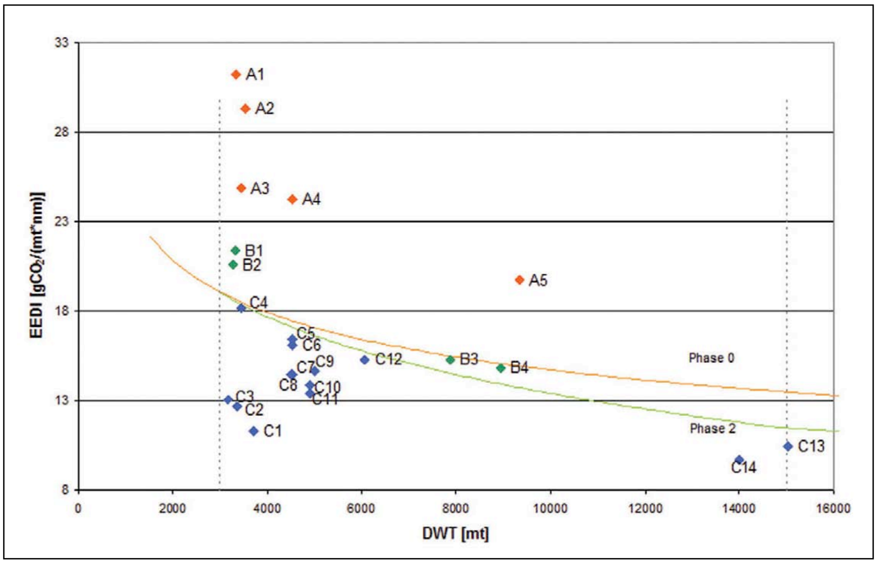



Figure 2: Attained EEDI versus Deadweight, for ships introduced in figure 1

Western European shipowners. The data of these ships was provided by the designer, builder or owner of each ship. Note that the level of detail of the comprehensive set of details in this database is much higher than the data from the IHS Fairplay database as used for establishing the EEDI Reference lines.

The parametric assessment showed that the mutual differences in attained EEDI values are a result of the many differences in design aspects ranging from specific fuel consumption to design draughts which is less than the summer draught. However, three main aspects are identified which explain a large part of the scatter (in random sequence).

1. differences in operational profile
2. application of cargo handling gear
3. structural enhancements related to additional class notations.

## Operational profile

General cargo vessels below 20,000dwt are, despite being "general cargo", commonly designed and optimised for a specific niche market. Consequently, the design of general cargo vessels varies much more than the design of tankers or bulk carriers, as there are many specific niche markets. Their common aspect however, is that all of the designs are suited to carry a wide variety of cargoes, even when they are optimised for a single cargo. For a number of the niche markets in which general cargo vessels operate, the operational profile requires a high minimum operational speed; for example, because a vessel operates on a round trip with a fixed schedule, or because a ship also needs to operate as a container feeder. Further, in some market segments the general cargo vessels need to compete with other modes of transport (in coastal trades) such as road or rail traffic, which also makes a high operational speed a prerequisite, or occasionally are chartered for liner services with a tight time schedule like a container trade.

The large differences in high minimum operational speed are one of the main causes of the high scatter of attained EEDI values found for general cargo ships. This was shown by Verhulst, Nieuwenhuis and Duursema (2012). For a selection of the ships in the database both the speed (Figure 1) and the attained EEDI (Figure 2) are plotted against the deadweight. The selection of ships are categorised on the basis of their attained EEDI value. The "A" ships have attained EEDI, which are much higher than the Phase 2 requirements for general cargo ships. The attained EEDI

| | | Ship A | Ship B |
|---|---|---|---|
| DWT | [mt] | 3600 | 29700 |
| VRef | [knots] | 15.1 | 15.1 |
| Lpp | [m] | 98.2 | 183.3 |
| Bm | [m] | 15.6 | 27.8 |
| Dm | [m] | 7.4 | 15.5 |
| Tsummer | [m] | 5.8 | 11.2 |
| Fn | [-] | 0.250 | 0.183 |
| PME | [kW] | 2137 | 5419 |
| PPTO | [kW] | 150 | 442 |
| CF | [t-CO2/t-Fuel] | 3.206 | 3.206 |
| S.f.c. | [g/kWh] | 180 | 180 |

Table 2: Particulars of two ships

values of "B" ships are just above the Phase 2 line, where the ships of group "C" meet the requirements easily. The figures show that the large differences in operational speed, is one of the main causes of the high scatter of Attained EEDI values.

An analysis of the performance of the vessels as used for this research by MARIN showed that considering their main dimensions, for most of the vessels very little or no performance improvement could be expected by re-designing the hullform or the propulsion train. Further improving the performance and thereby lowering the attained EEDI is thus only possible by changing the main dimensions, especially through increasing the length. However, for many of the small general cargo ships the main dimensions are bounded by constraints originating from the operational area. For example the length, beam and draught are limited in order to pass locks or to sail part of the time on inland trades.

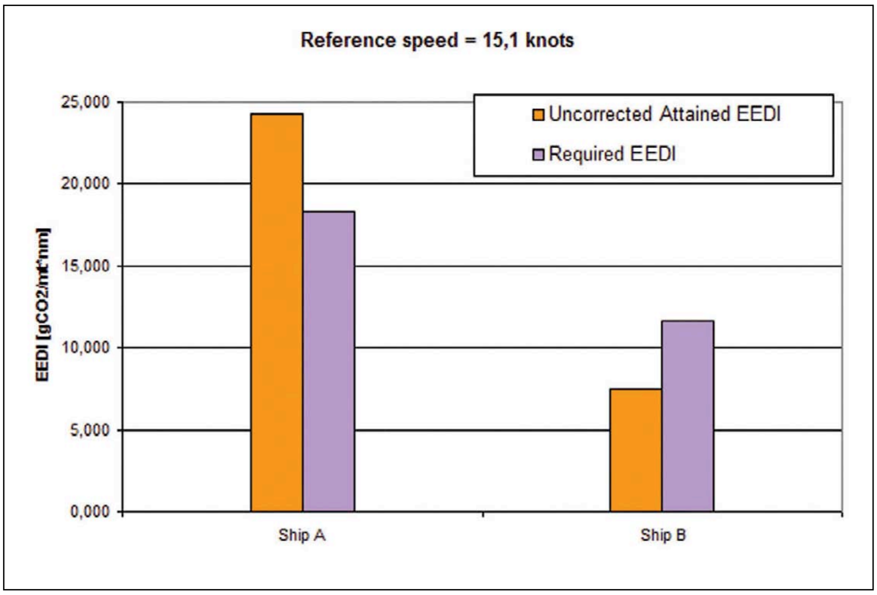
Without a correction factor to consider the large differences in required minimum operational speed, a considerable number of general cargo vessels as operating today could no longer be built. However, general cargo ships with a high minimum operational speed do have a clear "benefit for society". For example, whenever small general cargo ships with a high speed are no longer allowed, the same cargo needs to be transported by a larger vessel. However, these vessels will not be able to enter the same ports which the smaller vessels can enter. Consequently more transport from and to deep sea ports will be required, which in many cases will be done by road transport, further increasing the overall $CO_2$ emissions. Also, the absolute $CO_2$ emission of the larger ship is higher than that of a small vessel, even though most of the larger vessels do meet the EEDI regulations, as is shown in the following example.

Consider the two general cargo vessels of which the particulars are listed in table 1. The first ship, Ship A, is a small general cargo ship with a deadweight of 3,600tonnes, which is optimal for a specific trade in a specific area in which 3,500tonnes of cargo, and often much less, needs to be transported in a certain timeframe. The dimensions are limited due to constraints originating from the ports the ship has to call in the trade. To be able to ship the cargo on time, the ship is extensively optimised for a high reference speed of 15.1knots. This ship does not meet the requirements. The larger vessel, which does not have a limitation of the main dimensions, could also carry this cargo of 3,500tonnes (or less). Both the attained EEDI and the required EEDI of Ship A and B can be seen in figure 3. The attained EEDI of Ship B is less than a third of the attained EEDI and Ship B does comply with the requirements where Ship A does not comply. However, ship B is not able to enter the ports which ship A could enter and the actual amount of $CO_2$ produced by Ship B during the trade is 43% higher than the $CO_2$ produced by Ship A. Also see MEPC.65/INF.8 (2013).

To define a suitable correction factor for a high operational speed, the MARIN database was used to determine which parameters have a significant effect on the required power for general cargo ships. This database contains speed power measurement data obtained during around 1,000 model tests. For a selection of 88 of the vessels the quasi-attained EEDI values were determined over a range of speeds at the summer draught. To this end the deadweight of these ships was estimated by using an empirical formula, determined on the basis of a clear relation between deadweight and displacement found for the general cargo ships in the database which, was specifically created for this project. It was found, by a multiple selective regression analysis, that the parameter $Fn_{\nabla}^{2.3}Cb^{0.3}$ explained a large part of the variation in the quasi-attained EEDI values, with $Fn\nabla$ being the volumetric Froude number and Cb the block coefficient.

For the vessels in the project-database the attained EEDI and required EEDI were known and the parameter Fn∇2.3Cb0.3 had to be determined. To be able to focus on the effect of operational speed on the attained EEDI values, the attained EEDI values were corrected for ice class notation by a small correction in deadweight. The deadweight of the ships with cranes was

Figure 3: Comparison of EEDI values of Ship A and B



corrected for the weight of cranes, and ships with a large improvement potential were left out of the analysis. By plotting the ratio of the attained EEDI over the required EEDI versus the parameter $Fn_{\nabla}^{2.3}Cb^{0.3}$ a fair correlation was found. Putting a trend line (least squares line) through the data gives you a constant of 5.737. This trend line intersects with the ratio Attained EEDI/ Required EEDI is 1 there where $Fn_{\nabla}^{2.3}Cb^{0.3}$ is 0.174. Hence, the correction factor for operational speed became:

$$f_j = \frac{0.174}{Fn_{\nabla}^{2.3} Cb^{0.3}}$$

$$Fn_{\nabla} = \frac{V}{\sqrt{g\nabla^{1/3}}}, Cb = \frac{\nabla}{LBT}$$

The correction factor for operational speed is a correction on power. If fj is equal to or larger than 1, a fj value of 1 should be applied. Moreover Fn← should not be larger than 0.6. This is the largest volumetric Froude number based on reference speed in the general cargo database. By setting a maximum to this value future unforeseen excesses are avoided and the correction factor cannot be used for too high speeds, e.g. for planing ships outside the normal displacement mode. Furthermore, indirectly a minimum is set to the correction factor as well, which makes sure designing ships at higher speeds than those of the current fleet will be difficult.

## Loading gear

For many of the general cargo ships the versatility is enhanced by the application of loading gear. Typical types of loading gear applied on general cargo ships are cranes, sideloaders and ro-ro ramps. The cargo handling gear is essential for loading and unloading of cargo in ports where there is no loading equipment at all or when the capability of the equipment is not sufficient.

As a result of the applied loading gear, the lightweight increases and the deadweight decreases. Hence the attained EEDI will increase. So differences in attained EEDI values between ships with equal dimensions are a result of the applied loading gear. This is one of the main causes of the high scatter of attained EEDI values of general cargo ships. See Figure 2 for an example of a ship with a combination of different types of loading gear. Without general cargo ships equipped with cargo handling equipment, all cargo first has to be transported by road or train to ports with the adequate equipment, before it could be shipped overseas. Subsequently the same is true for the unloading part of the transport chain. The increased "pre and post" transport would increase the overall $CO_2$ emissions within the transport chain, as most of it will be done by truck.

It is therefore proposed to include a correction factor for cargo handling gear.

Figure 4: *Lady Anneke* aground during loading operations

A correction factor that compensates for the differences between general cargo ships in cargo handling gear reduces the wide scatter for small general cargo ships. The derived correction factor fl compensates the capacity of the vessel for the weight of cranes, side loaders and ro-ro ramps.

So: $f_l = f_{cranes} \cdot f_{sideloader} \cdot f_{RoRo}$

Where:

$f_{cranes} = 1$ If no cranes are present.

$f_{sideloader} = 1$ If no sideloaders are present.

$f_{RoRo} = 1$ If no ro-ro ramp is applied.

For a number of the vessels in the database, the total weight increase of the lightship as function of the maximum safe working load (SWL) times the reach was known. Based on this found relationship the factor $f_{cranes}$ is defined as:

$$f_{cranes} = 1 + \frac{\sum_{n=1}^{n} (0.0519 \cdot SWL_n \cdot Reach_n + 32.11)}{Capacity}$$

$$f_{sideloader} = \frac{Capacity_{No\ sideloaders}}{Capacity}$$

$$f_{RoRo} = \frac{Capacity_{No\ RoRo}}{Capacity}$$

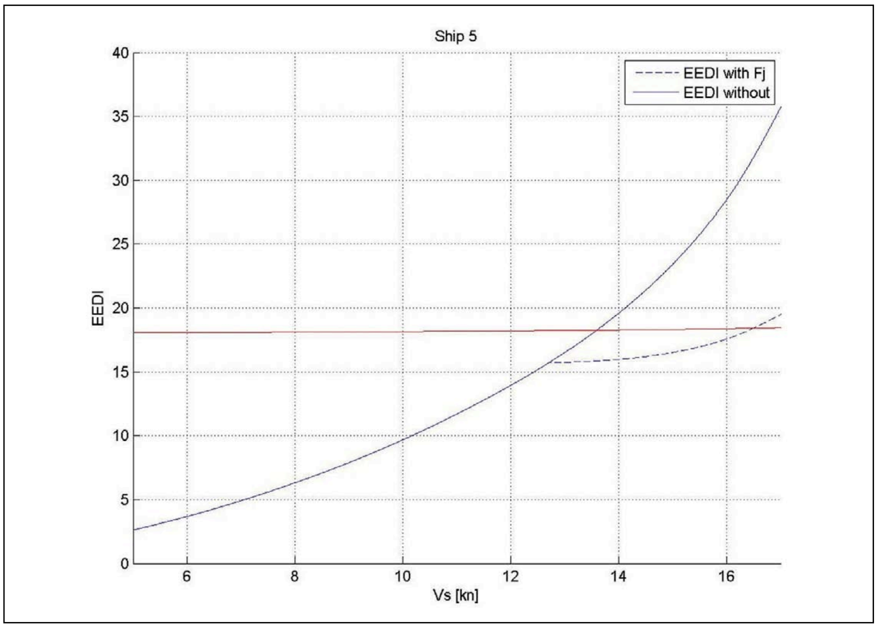
Ro-ro ramps and sideloaders are, in contradiction with cranes, ship specific solutions and commonly ‘one-off’. It is, therefore, much harder to catch the weight increase of the lightweight in a formula. Therefore the correction factors $f_{RoRo}$ and $f_{sideloader}$ are calculated as:

## Additional class notations

Additional class notations are related to voluntary constructional enhancements, which are applied to enlarge the operational area or to enhance the cargo (handling) capacity. Examples of additional class notations are “strengthened for discharge with grabs”, “strengthened tanktop for heavy cargoes” and “strengthened bottom for loading/unloading aground”. For ships with the latter given example, the bottom of the ship is strengthened to lay aground during loading operations in shallow tidal ports. See Figure 4.

Due to the constructional strengthening the lightweight of the ships increases considerably, especially when a combination of class notations are applied. The increase of the lightweight is at the expense of a lower deadweight, and as such on the attained EEDI. Differences

Figure 5: The effect of the correction on the EEDI-speed relationship, the attained EEDI values for a single ship over a range of speeds



in additional class notations between ships of identical main dimensions result in differences in attained EEDI values. Therefore, the differences in additional class notations are one of the three main causes identified for the high scatter of attained EEDI values as found for general cargo ships.

Without general cargo ships with additional class notations as "loading aground", the cargo needs to be transported to deepsea ports. This results in more pre and post transport, which is usually done by truck. An increase in transport by truck results in an overall increase of $CO_2$ emissions.

It is proposed to not implement a new correction factor for this purpose, but to correct the attained EEDI value for additional class notations via the already existing correction factor for "voluntary structural enhancements", $f_{iVSE}$. However, it is not explicitly mentioned in the current Guidelines on calculations of EEDI that the correction factor may be used for this purpose. Therefore, it is proposed to mention explicitly that the correction factor for voluntary structural enhancements can be applied to account for additional class notations.

## Results of correction factors

The effect of the inclusion of the three correction factors can be seen in the next two figures. In the first figure the attained EEDI values of the general cargo ships in the database are plotted against deadweight without any correction factors applied. A power law trend line through these points is included, with a $R^2$ of 0.403. The phase 0 and 2 required EEDI lines are also shown.

In the second figure the proposed correction factors for loading equipment, additional class notations and operational speed are include in the EEDI values. The value of $R^2$ increases to 0.555. Some of the larger corrections apply to a few small high speed ships, because of their relatively large volumetric Froude number. The graphs show that applying the correction factors does not mean that all ships automatically fulfil the EEDI requirements. It is still crucial to fully optimise the ships and even then a group of highly optimised ships still remain for which additional measures have to be taken.

## MEPC and additional research

The proposal for the inclusion of three correction factors for general cargo ships was discussed during MEPC 64. Some parties of the Marine Environmental Protection Committee (MEPC) were critical towards regarding the correction factor for higher minimum operational speed. Additional research was necessary to investigate the proper functioning of the correction factor. The focus of this additional research was on the effect of the correction on the EEDI-speed relationship, so the attained EEDI values for a single ship over a range of speeds (as if the installed PME was changed). This was done for all vessels in the database. An example is given in the following figure:

The blue line represents attained EEDI values calculated over a range of speeds, using available speed/power data from model tests over a sufficient large range. For each speed the required installed MCR power and weight was calculated, which influences also the DWT somewhat, because the calculations were done for constant displacement. Therefore the red required EEDI line increases slightly. Applying the correction factor for speed fj to the attained EEDI curve, results in the dashed line, where differences only become noticeable above speeds where $f_j$<1.

The slope of the attained EEDI line depends on the exponent of the speed/power curve of the ship. This exponent depends on the amount of wave resistance, but is generally around three for lower speeds. Assuming the auxiliary power in the nominator of the EEDI formula is proportional to PME and the other parameters do not depend on speed, EEDI will vary with speed to the power of approximately two, because $V_{ref}$ is linearly present in the denominator. Because the volumetric Froude number and ship speed are raised to the power of 2.3 in the factor fj, which is in the same order of magnitude as the slope of the attained EEDI, the speed dependency of corrected attained EEDI curve can disappear more or less, at least for the lower speeds.

This effect can be seen in the figure, where at speeds of around 13knots the corrected EEDI line is quite flat. For most other ships though the corrected EEDI curve is rising more steeply with speed, which means the speed to power exponent is well above three. The reduced slope of the attained EEDI is a consequence of the choice for speed compensation. As long as the EEDI line doesn't decrease with speed, the proposed correction factor is not conflicting with the principles of the EEDI. For ships designed for high speeds, it is not very likely that the speed to power exponent is below 3.3 near the reference speed.

The proposed correction factors have been approved by the MEPC 65, with the aim to adopt the proposal during MEPC 66 in March/April 2014. The correction factors have been adopted in the draft amendments to the 2012 Guidelines on the method of calculation of the attained EEDI for new ships, see MEPC 65/WP.10 Annex 2 (2013). *NA*

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# Financing issues plague mid and small-sized Chinese yards

Maritime lawyers think that the authorities should improve the pledge system for ships that are under construction in order to help shipyards obtain bank financing, and that private fundraising should be standardised and regulated for shipbuilding and non-bank borrowing activities

In recent years, loss-making shipbuilding orders have become common as new ship orders have diminished and shipbuilding costs increased. This has hindered the financing that privately-owned yards could obtain; inter-shipyard borrowings or private funding has added to the liquidity pressure on private yards.

Shipbuilding is capital intensive, high risk, and has a relatively long return cycle. China, as an emerging shipbuilding force, has strong demand for ship financing. Against the backdrop of a sluggish shipping market which has been stymied by the global financial crisis, shipbuilding enterprises in east China's Zhejiang province – one of the most important ocean economies in the country - should receive support in terms of policy, tax, financing, technology and human resources from the country.


Signing ceremony of the cooperation agreement between the Bank of Rizhao and a shipyard

There are many privately-owned shipbuilding and related companies in Zhejiang and they have been hit hard. As newbuilding orders have decreased, ship prices have fallen and raw materials and labour costs have increased and shipbuilding costs are on the rise.

Moreover, funding channels such as bank financing, inter-shipyard borrowings and private funding have been blocked. These have added on the liquidity pressure of mid- and small-sized shipyards. Some of them recorded huge losses and are on the verge of bankruptcy.

Solving the financing problem of mid and small-sized shipyards has become an important issue for China's shipbuilding industry.

According to common practice in shipbuilding, shipowners pay the ship price via five equal instalments from the deposit paying stage to delivery. Shipyards need to prepay a relatively large portion of the shipbuilding cost in the early stage of shipbuilding. While new orders are ample, shipyards can maintain daily operations as funds are flowing in from orders at different shipbuilding stages.

Take shipyards in Taizhou as an example, in 2003-2007 when the shipbuilding market was booming and yard prices were rising, shipbuilding profit margins could be as high as 20%-30%. During that period of time, shipyards were able to obtain financing relatively easily from banks or other private funding channels. But now, the shipbuilding sector in Taizhou has been severely hit by the financial crisis.

As the shipbuilding market has cooled new ship prices have dived. In the first half of 2008, a 30,000dwt bulk vessel was priced at RMB300 million (US$49 million). Prices of such ships fell to RMB240 million (US$39.12 million) in 2009; and further to RMB170 million (US$27.71 million) in 2011 and RMB160 million (US$26.08 million) in March 2012. Ship prices dropped more than 50% in a three year period.

Volatility in the market caused Chinese banks, which have been involved in ship financing for a comparatively short period of time, to become more cautious in lending. According to banking sources, nearly all banks in Taizhou have stopped issuing new secured loans to shipyards and shipping companies. Some have even requested borrowers repay before their loans mature. Taizhou is not an isolated case. The downturn in shipbuilding has led to the withdrawal of private funding too, hitting the smaller yards hardest.

There are two main factors affecting financing for small and mid-sized shipyards; the global economic downturn and financial crises have severely struck the shipbuilding and shipping sectors making it a high-risk industry in the eyes of banks. While the market is volatile, it is hard for banks to assess risks for issuing


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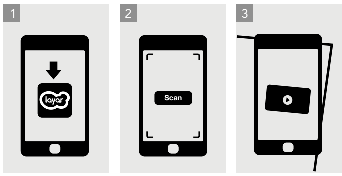


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credits. Therefore, banks choose to halt lending or request early repayment from smaller shipyards. Industry experts estimate, around RMB20 billion (US$3.24 billion) in capital has left the shipbuilding market.

Secondly, there is a weakness in the operational model of small to mid-sized shipyards. In Taizhou region, it is common for shipbuilding companies to build a dock and recruit shipbuilding professionals to rent the dock and operate it. The shipyard only earns the rent and management fee of the dock. This operational model is rarely seen in other parts of the world.

## Model uncertainties

This model has created many uncertainties and has led to poor management, a lack of transparency of shipyards' financial status and a lack of long-term operational and sales strategies. In terms of human resource management, shipyards have no motivation to develop their own bank of talent or to raise shipbuilding standards. The integrated capability of these shipyards is weak and it is hard for them to navigate through a volatile market. In addition some yards may have other weaknesses, such as on a technological level or in operational and financial management.

Bank loans are the main funding channel for small yards. These yards use land, equipment (such as cranes and engines), as well as ships under construction, as collateral in order to get loans. The uniqueness of the shipbuilding industry has further created some legal issues over bank borrowing such as using orders for new vessels as surety to secure loans.

In order to reduce lending risks banks usually require borrowers to provide assets as security, however, as the building of a ship is a long process and requires large amounts of up front capital investment, it is not enough for shipbuilders to pledge only ships that are completed. In order to encourage the development of the shipbuilding industry, it is a must to set up a system for shipyards to pledge vessels under construction to get funding. In China, this is governed by the Maritime Code and the Property Law. According to article 14 of the Maritime Code, mortgages may be established on a ship under construction; in registering the mortgage of a ship under construction, the building contract of the ship shall be submitted to the ship registration authorities and in accordance with article 180 (v) of the Property Law, ship construction may be mortgaged.

However, both articles were rather vague in that they only mention the mortgage of a ship under construction is allowed without detailing the procedure of setting up such a mortgage. Without detailed guidelines as to how a mortgage of this type can be established, banks often avoid using ships under construction as security to reduce the possible legal risks.

There are other unresolved issues regarding the mortgage system for ships under construction. The definition of ships under construction is vague. According to the Ship Registration Rule, a "ship under construction" means a ship whose keel was laid or a ship that is at a similar stage of construction.

It may be clear when the keel was laid, however, it is difficult to define what "similar stage of construction" means. This has created uncertainty for the mortgage of ships under construction. In addition, according to article 3 of the Maritime Code, the definition of ship does not include ships under construction. Therefore, the property rights for ships under construction are different from those of ships that are already operational and remain uncertain. If borrowers want to mortgage ships under construction they must make sure they own the property rights to the ships. Moreover, there is no regulation detailing how to define the property rights of ships under construction.

## Private fundraising

Private fundraising in China's shipbuilding industry has many different forms and involves a wide range of people. Private fundraising for shipbuilding is similar to a pyramid model or multi-layer marketing in China, but there are significant differences.

Private fundraising for shipbuilding has a ship under construction as an investment target, while multi-layer marketing does not. To understand the legal issues of such a financing model, we must clarify how the law defines such multi-layer investment.

In practice, there are usually only one to two legal owners of a ship. But, there maybe several layers of hidden investors behind these one or two shipowners. According to the agreement between these hidden investors and the legal shipowners, the hidden investors have a right to the ship under construction, however, the legal relationship is not well-defined and it would be difficult for the court to judge the rights and responsibilities between the parties.

It is unclear whether the relationship between legal owners and hidden investors should be treated as a partnership or something else. Some experts believe that under this kind of investment model, the relationship between the legal owners of the ship and the hidden investors should be treated as a limited partnership for the following reasons:

1. From a historical point of view, the concept of a limited partnership stemmed from commenda, a form of business organisation generally used for financing maritime trade in 10th century Italy. In a commenda, the travelling trader was given a ship, goods and money, etc, by his investment partner for the trader to operate, and the trader could share one-fourth of the profit in return. The travelling trader had unlimited liability, but his investment partners on land were shielded and could get three-fourths of the profit. Later, this form of business organisation evolved into today's limited partnership. A limited partnership is suitable for high-risk investments.
2. A partnership is formed by two or more parties and has the following characteristics: the partnership is established under voluntary agreement of the partners; capital is provided by all partners and profits are shared by all partners; partners have to bare unlimited liability. In the case of private ship financing in China, the sponsor of the new ship usually has a high reputation in the community and is more familiar with shipping.

Therefore, the sponsor will be in charge of management of the shipbuilding process and operation of the ships. While hidden investors are pure capital providers who share the profits as agreed according to their shares in the ship. If hidden investors are treated as unlimited partners and have to share unlimited liability, it would contradict the intention of the law.

3. In a limited partnership, there is at least one partner with limited liability and at least one partner with unlimited liability. Partners with limited liability only share the liability of the partnership to the extent of the capital he has invested in the partnership and are not liable to repay debt for the partnership using his other assets. Limited partnership has the following characteristics: Firstly, it must be formed voluntarily, and with an article of association that adheres to the law of forming a limited partnership which has to be registered. Secondly, both partners, either with limited or unlimited liability, are to invest in the company capital and share profits. Thirdly, partners with limited liability are not involved in the company's operations. Fourthly, partners with limited liability bear only the liability of the partnership to the extent of the capital he has invested in it; while partners with unlimited liability bear the liability of the partnership to an unlimited extent and have to repay debt for the partnership using his other assets. Legal experts believe that the Chinese model of private fundraising for shipbuilding should be treated as a limited partnership legally, or dispute between partners of private fundraising for shipbuilding could be resolved according to laws that regulate limited partnerships.

## Non-bank borrowing

Non-bank borrowing here means borrowing between citizens and legal entities. The agreement between the two parties is deemed effective as long as they truly intend to make the agreement. As a direct funding means, non-bank borrowing is convenient to businessmen and provides an investment opportunity for citizens' money. Mid- and small-sized companies often obtain funds via non-bank channels. In general, non-bank borrowing often charges higher interest and over shorter periods.

Borrowers are usually required to repay the capital and interest once the debt matures. Therefore, there are seldom disputes between the lenders and borrowers. The main issue is the setting of interest rates. According to article 211 of Contract Law in the PRC, "under a contract for the loan of money between persons, the interest rate on the loan may not contravene the relevant provisions of the State concerning the limits on the loan interest rates."

According to the ruling of the Supreme People's Court, the interest rate of non-bank borrowing can be higher than the interest rate offered by banks, but cannot exceed four times the interest rate offered by banks. For those loans that come with higher interest rates the court would not endorse any extra interest payments beyond four times of the interest rate offered by banks.

## Meeting smaller shipbuilders' needs

There must be a change in the operational model for smaller shipyards; a majority of these yards must be eliminated. Many mid- and small-sized shipyards are to be merged or restructured to get rid of excess capacity and encourage technological development.

Firstly, the authority needs to establish a comprehensive pledging system for and define the property rights of ships under construction. Legal experts say that in a shipbuilding contract, the shipowner should have the property rights of the ship under construction and the shipowner can pledge the ship under construction to banks to obtain financing.

Banks can release funds in instalments at set points in the ship construction process to reduce risk and can auction the ship when a default happens. At the same time, the authority should launch detailed regulations on the pledging of ships under construction. For larger ships, the risk will be higher and volatility of ship prices may endanger banks and other financial institutes. Therefore, a more creative approach should be adopted to reduce risk for lenders, such as using reinsurance to motivate banks to lend to the shipbuilding sector.

Second, the authority should establish regulations to standardise private fundraising for shipbuilding. This can utilise the private source of funds to develop the shipbuilding sector and raise the shipbuilding capability of the local shipbuilding enterprises.

Private fundraising for shipbuilding should follow the model of limited partnership. This practice has been adopted in other sectors in China in the form of private equity funds. Sponsors who manage the shipbuilding process can be unlimited partners who will also draft the partnership agreement and articles of association. Investors who only provide capital can join as limited partners with limited liability to share the profits according to the size of his stake. While all limited partners have exited the funds, or when all limited partners have become unlimited partners, the partnership will become an unlimited partnership. The authority can set up a registration system to monitor the fund raising market.

Thirdly, authorities must regulate non-bank, private borrowing. The common problem of non-bank, private borrowing is that the interest rates are usually higher than four times the interest rate offered by banks and the lenders are not fully protected by law. The authority must adjust bank interest rates to reflect the local economic status. Meanwhile, it is necessary to have a registration and monitoring organisation set up to standardise non-bank, private borrowing. It may also be necessary to establish a non-bank, private borrowing market to help cooperation between shipyards and private lenders.

Finally, a cooperative development fund must be established. It is suggested that when the shipbuilding market bottoms out, a cooperative development fund for shipbuilding should be established by the government, industry organisations and sizeable shipyards to provide funds and support to mid- and small-sized private shipyards to upgrade their shipbuilding capability, and enhance the competitiveness of local shipyards in national and international markets. *NA*

# Decreasing the resistance

Chugoku Marine Paints (CMP) has advanced its coatings technology as Hirohisa Mieno and Hiroshi Masuda explain in their paper 'An Experimental Study for Friction Resistance of Ship Hull Sprayed with Paints'

Global warming resulting from greehouse gas (GHG) emissions and depletion of fossil fuel resources are global concerns. An investigation by the International Marine Organization (IMO) indicated that GHG emissions by international shipping are currently around 2.7% of the total global emissions.

Hence IMO adopted the revision of MARPOL ANNEX VI to establish the Energy Efficiency Design Index (EEDI) in July 2011. The EEDI is calculated during the design phase of a ship and is confirmed during vessel sea trials. The EEDI demands will be tightened step by step until 2030; therefore, each ship builder will be obliged to improve the energy efficiency of the vessels it builds, using all technical abilities including hull optimisation and so on to reduce fuel consumption and thereby decrease GHG emissions.

Friction resistance is responsible for about 60% to 80% of the whole ship resistance. In an effort to improve efficiency air lubrication systems(1) and the Thomas effect(2) have been proposed as promising methods. But, at the moment these systems can only be used on a limited number of vessels or only experimental results have been obtained.

Antifouling paints have been used for prevention of the attachment of marine organisms. Those paints have greatly contributed to maintaining the ships' speed and improve energy efficiency. Antifouling paint is applied on every ship's hull to achieve improvements in performance.

It is a well-known fact that friction increases with increased surface roughness. It is therefore important to create a surface as smooth as possible in the new building phase. Prediction of the ships' performance from the roughness of the paint surface has been tried for long time. Hull roughness was conventionally measured using a BSRA roughness analyser. This instrument measures the gap between maximum peak and trough in a 50mm evaluation length. The instrument has been in use for a long time because this method is convenient to use at shipyards. Influences of the other surface roughness characteristics on friction have been reported. For example D.Byrne reported on the effects of texture parameters for ships(3) Sasajima also reported roughness height and wavelength parameters influence the performance of actual ships and flat plate test(4) Hence understanding the influence of the surface roughness profile on friction is important to be able to reduce the friction resistance.

In this study the influence of surface roughness on friction was measured using Double Rotating Cylinder Equipment. The roughness is measured with a Laser Displacement Meter and the surface parameters are investigated by the JIS B 06015) method. Roughness of actual vessels was measured by Replicate Method.

## Material and method

Double rotating cylinder equipment is used to measure the friction resistance due to surface roughness. A model ship or a flat plate in a towing tank is normally used to measure the ships' resistance. However in the case of friction that was caused by real roughness, the friction increase can hardly be observed in liquids with a low Reynolds number under circumstances of limited speed and limited test-piece length. The effect of the roughness might not be observed because at low Reynolds numbers the thickness of the viscous sub-layer is higher than the roughness height. This limitation is already indicated by Sasajima's experiment(4). In the double rotating cylinder test this limitation is overcome. A thin viscous sub-layer such as is found in actual vessels is reproduced combining a small gap and high rotating speed. A cylindrical tank with an inner diameter of 320mm, made from smooth stainless steel, filled with deionised water is rotated using an inverter controlled motor. In order to keep the viscosity of the water constant, it is kept at a constant temperature of 23°C using a thermo controller.

In this tank a cylinder is immersed with a diameter of 310mm and 300mm high made out of polyvinylchloride. The torque on the inner cylinder is measured using a torque meter attached to the upper shaft. The gap between the two cylinders is 5mm minus the film thickness. The speed of the outer cylinder can vary from 100 to 1,000rpm. To simplify the discussion in this paper, the results for the 1,000rpm test is focused on.

The Friction Increasing Ratio FIR (%) is defined in Equation (1). T is equal to the torque measured using a painted inner cylinder and T0 is the torque measured on a smooth surface with the same gap width (5mm – film thickness).

$$FIR\ (100\%) = \frac{T-T_0}{T_0} \times 100$$

## Procedure to prepare the inner test cylinder

The roughness of the inner cylinder is artificially made by spraying a binder coat on the inner cylinder under specific conditions with regards to spray pattern width, distance between spray gun and cylinder and air pressure. Antifouling paint is painted on the artificially roughened binder coat. Tested antifouling paints are a foul release coating (FRC), a new generation self-polishing coating (N_SPC) and a conventional self-polishing coating (C_SPC). To confirm the effect of low roughness the C_SPC and the N_SPC were sprayed on the cylinders directly. An extremely rough surface was created by creating dry spray (DS) by spraying binder coat in an extremely wide pattern from a great distance using low air pressure. According to the difficulty of measuring the film thickness of these cylinders and the film thickness of a single coat is estimated as 125microns and a double coat as 250microns.

## Roughness analysis of painted cylinders

The test cylinder is set to the roughness measurement equipment. The displacement from the rotating cylinder is measured by Confocal Laser Displacement Meter (KEYENCE LT-8020) that is fixed on the equipment. 4,000 datapoints were generated in one meter in round (one measurement line) hence the rotating speed of the cylinder was adjusted to 0.64rpm. Therefore the measurement pitch is 250microns. Measurements were conducted on 10 lines starting on 50mm from the bottom to the top by traversing down the cylinder.

The spacing of each line was 25mm. Each measurement line is divided into 20 sections, and each parameter is calculated in an evaluation length of 50mm. The roughness parameters are calculated according to JIS B 0601.5) Rz is maximum height of profile, Rzjis 10 point height of profile, Rc mean height of profile elements, Ra arithmetical mean deviation of the profile, Rq root mean square deviation of the profile, Rsk skewness of the profile, Rku kurtosis of the profile, and Sm mean spacing of profile element. After the calculation of parameters, average of each profile parameter of the sections was calculated and adopted as representative parameters of each cylinder.

## Roughness analysis of actual vessels

Information about the surface roughness profile of actual ships' hulls is limited and difficult to obtain. To solve the latter problem the Replicate method was developed. A thermo plastic resin is used for replicating the hull roughness. This thermo plastic resin is easily softened by hot water, the replicated shape is settled after cooling and the sample can be easily removed from the hull. Hence this method is suitable for gathering real hull information.

These replicated samples are brought to the laboratory and measured using a Laser Displacement Meter by scanning in a 30mm x 30mm area as 121points for 121 lines. Therefore, the measurement pitch is 250microns, and the average Rz and Sm of each line was calculated as a representative parameter of each sampling point. In this research the hulls of four vessels were investigated. The vessels were built in the same shipyard during the same period. One vessel is painted with the N_SPC and the others were painted with the C_SPC. Each vessel had five testing points from the starboard side and the port side of the vertical bottom and the centre of the flat bottom respectively. The five testing points were the forward part, the middle part, the middle pre-erection part, the after erection part, and the after part of each bottom. According to the building schedule, replicating could not be conducted on some erection parts of vessel No.3 and No.4.

## Result and discussion

Reproducibly of the cylinder test was confirmed using only the standard inner cylinder that is 310mm in diameter. For the duration of the one year test period, the torque difference of each measurement is within 6.48(N · m) ± 0.5% at 1,000rpm. Because the gap between the inner cylinder and the outer cylinder is only 5mm the result has to be adjusted for film thickness. To confirm the thickness effect, a 309mm and a 311mm smooth cylinder were made by lathe processing. As shown in Figure 1, for the 311mm cylinder as +0.5mm film thickness the torque is 6.84(N· m), for the 309mm cylinder as -0.5mm film thickness is 6.30(N · m). From Figure 1 the torque for each film thickness is estimated. For example in the case of the 250microns 6.63 (N · m) is estimated and in the 125microns case 6.55(N · m) is estimated as torque of a smooth surface. Figure 1 Film thickness effect for torque on smooth surface.

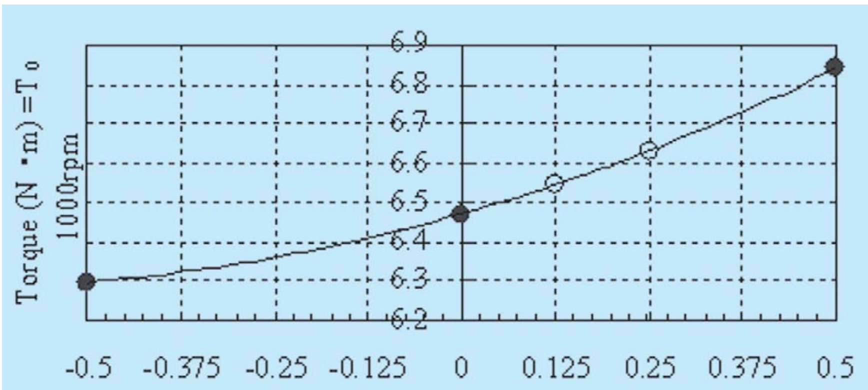
## Relation between painted surface roughness

Roughness parameters and the FIR of each cylinder are shown in Table 1. Results of the correlation analysis on each roughness parameter are shown in Table 2. A strong positive correlation of Rz, Rzjis, Rc, Ra, Rq was seen. As shown in Table.1 Rsq and Rku tend to approximate to 0 and 3 respectively hence correlation is not observed. Sm and the amplitude parameters show a weak negative correlation. This result indicates the sprayed roughness is distributed in a similar fashion to a Gaussian distribution. The amplitude parameter can be represented by Rz, This is a useful parameter because it can be considered as the BSRA roughness parameters.

The definition of Rz in 50mm evaluation length is almost the same as BSRA roughness. As a result, Rz and Sm are selected for characterising the surface profile. The results for each test coating can be found in Table 3. The relationship between Rz and FIR is shown as a graph in Figure 2. DS are plotted as the △ symbol, C_SPC as the ◇ symbol, N_SPC as the ○ symbol, FRC as the □ symbol.

Friction increasing was observed according to the increase of Rz. Even at the same Rz value, FIR differences are observed between FRC, N_SPC, C_SPC and DS. The relationship between Sm and FIR is shown in Figure 3. Sm of DS ranges from 2,000 to 3,000microns and FIR is more than 25%. Sm of C_SPC ranges from 3,000 to 4,500microns of N_SPC from 4,000 to 7,000micron and of FRC Sm is more than 8,000micron. FIR for FRC and N_SPC is less than 2%. A lower Sm-value tends to increase FIR more than a higher value. Sasajima (4 reported a correlation between the squared height parameter divided by wavelength as H2/ λ and the friction coefficient. When in this experiment Rz is considered as H and Sm is

Figure 1: Film thickness effect for torque on smooth surface



considered as λ there should be a correlation between FIR and Rz2/Sm.

This is shown in Figure 4 FIR and Rz2/Sm showed a positive correlation except for DS and this result is in good agreement with Sasajima's experiment (4. 2.62 x Rz2/Sm might be available for a roughness prediction of FIR. The out of correlation of DS was probably due to the very fine and extremely hard to accurately measure Rz and Sm values in 250microns pitch measurement. For more accurate measurements a shorter pitch experiment is necessary. FRC is a silicone type paint and has low surface energy and an excellent self-levelling property. This could well explain why FRC surfaces have low Rz values and high Sm values. N_SPC is a two pack type new self-polishing coating. Its main binder is a newly developed low viscosity resin. This paints application properties was confirmed in a wind tunnel test. During the test a reduction of spray dust and an improvement of paint transfer to the substrate were observed. Those properties could result in a lower Rz and a longer Sm.

Table 1: Roughness parameters and FIR cyclinders

| | Rz (micron) | Rzjis (micron) | Rc (micron) | Ra (micron) | Rq (micron) | Rsq | Rku | Sm (micron) | FIR (%) |
|---|---|---|---|---|---|---|---|---|---|
| N_SPC | 51.8 | 33.5 | 22.5 | 8.5 | 10.7 | 0.3 | 3.1 | 5914 | 0.80 |
| N_SPC | 18.4 | 11.1 | 7.1 | 3.2 | 3.9 | 0.1 | 2.8 | 5917 | 1.16 |
| FRC | 54.3 | 32.3 | 27.4 | 9.7 | 12.1 | 0.2 | 2.8 | 8506 | 1.21 |
| FRC | 55.0 | 33.6 | 27.6 | 9.9 | 12.3 | 0.2 | 2.9 | 8321 | 1.44 |
| N_SPC | 58.1 | 36.3 | 26.4 | 9.6 | 12.1 | 0.3 | 3.4 | 6694 | 1.46 |
| N_SPC | 66.2 | 43.6 | 25.7 | 9.8 | 12.7 | 0.7 | 3.9 | 4400 | 1.57 |
| C_SPC | 21.0 | 13.9 | 8.0 | 3.4 | 4.2 | 0.1 | 2.9 | 4225 | 3.79 |
| C_SPC | 99.5 | 71.3 | 42.9 | 15.5 | 19.5 | 0.3 | 3.2 | 3927 | 5.99 |
| C_SPC | 61.3 | 45.2 | 24.2 | 9.0 | 11.4 | 0.4 | 3.4 | 3173 | 6.30 |
| C_SPC | 86.2 | 59.9 | 35.5 | 13.0 | 16.6 | 0.6 | 3.6 | 4133 | 7.00 |
| C_SPC | 84.4 | 61.1 | 35.9 | 13.2 | 16.5 | 0.3 | 3.1 | 3838 | 7.09 |
| C_SPC | 98.7 | 71.0 | 42.4 | 15.4 | 19.4 | 0.3 | 3.1 | 4007 | 7.87 |
| C_SPC | 85.1 | 62.3 | 36.5 | 13.4 | 16.7 | 0.2 | 3.0 | 3927 | 7.93 |
| C_SPC | 103.0 | 76.9 | 43.0 | 15.8 | 19.8 | 0.2 | 3.1 | 3244 | 8.54 |
| C_SPC | 130.9 | 97 | 53.7 | 19.5 | 24.8 | 0.6 | 3.6 | 3167 | 11.2 |
| C_SPC | 161.3 | 116 | 63.4 | 22.8 | 29.6 | 0.8 | 4.2 | 3096 | 21.6 |
| DS | 79.6 | 59.8 | 30.5 | 11.5 | 14.6 | 0.2 | 4.1 | 2568 | 29.1 |
| DS | 93.8 | 72.3 | 38.7 | 14.4 | 18.0 | 0.1 | 3.0 | 2706 | 29.4 |
| DS | 104.5 | 80.2 | 42.2 | 15.8 | 19.7 | 0.1 | 3.0 | 2683 | 36.2 |

Table 2: Correction analysis between each surface parameter

| | Rz | Rzjis | Rc | Ra | Rq | Rsq | Rku | Sm |
|---|---|---|---|---|---|---|---|---|
| Rz | 1.00 | | | | | | | |
| Rzjis | 0.99 | 1.00 | | | | | | |
| Rc | 0.99 | 0.98 | 1.00 | | | | | |
| Ra | 0.99 | 0.98 | 1.00 | 1.00 | | | | |
| Rq | 1.00 | 0.98 | 1.00 | 1.00 | 1.00 | | | |
| Rsq | 0.55 | 0.50 | 0.52 | 0.51 | 0.54 | 1.00 | | |
| Rku | 0.50 | 0.48 | 0.42 | 0.43 | 0.46 | 0.79 | 1.00 | |
| Sm | -0.57 | -0.64 | -0.47 | -0.50 | -0.50 | -0.21 | -0.43 | 1.00 |

Table 3: Roughness characteristics of each surface

| | Rz (micron) | Sm (micron) | FIR (%) |
|---|---|---|---|
| N_SPC | 18.4 – 66.2 | 4400 - 6694 | 0.80 – 1.57 |
| FRC | 54.3 – 55.0 | 8321 - 8506 | 1.21 – 1.44 |
| C_SPC | 21.0 – 161.3 | 3096 - 4225 | 3.79 – 21.6 |
| DS | 79.6 – 104.5 | 2568 - 2706 | 29.1 – 36.2 |

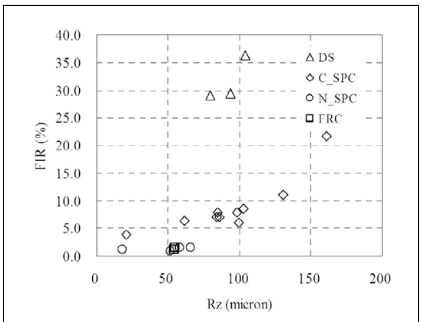
## Vessel roughness parameters

As shown above a sprayed surface can be classified by Rz and Sm. And its FIR might be predicted from Rz and Sm. Currently there is not enough information on roughness parameters on actual vessels. Thus far measuring sufficient roughness data on actual vessels has been impossible. However, with the Replicate method described in 2.4 the roughness of a ships' hull can be measured. Rz and Sm distribution is shown as a three dimensional bar graph on Figure 5. Estimated FIR (E_FIR) can be calculated from average Rz and Sm using the equation that is obtained from the cylinder test (3.2).

$$E\_FIR(\%) = 2.62 \times \frac{Rz^2}{Sm}$$

The data from the actual hull surveys are given in Table 4

Figure 2: Relation between Rz and FIR



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# Responding to market moves:
## The METS success story

**In an era where trade shows in every industry sector have been forced to re-evaluate their raison d'etre, one event in the leisure marine world continues to go from strength to strength. Some say it's the ideal location in Amsterdam, others the no-nonsense B2B atmosphere that attracts marine professionals and businesses in ever greater numbers. But there is a third factor behind the METS success story... the show's ability to listen to the market and diversify into new areas.**

**25 years and still growing strong**
METS - the Marine Equipment Trade Show - celebrated its 25th anniversary in 2012 as the world's largest and most visited leisure marine trade show. Despite the recession, the event attracted an impressive international attendance and the number of exhibitors remained exceptionally high. The fact that almost half of the exhibitors pre-booked stand space for 2013 before METS 2012 had even closed speaks volumes for the value attached to this annual gathering of the global marine industry.

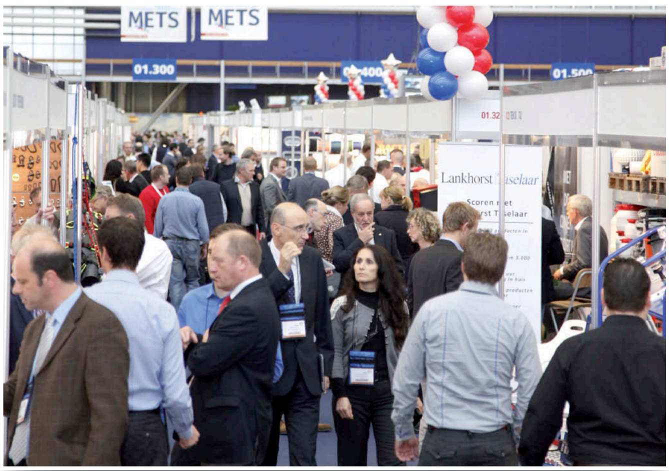
"It is clear that exhibitors and visitors alike welcome the fact that METS is strictly trade-only," explains Irene Dros, Domain Manager of Amsterdam RAI Convention Centre, which has successfully organised METS for the past quarter of a century. "Keeping our focus firmly on products attracts people from over 100 countries and has also led marine industry associations from 15 countries to set up their own pavilion."

The METS organisers have also enhanced the show's diversity by introducing specialist pavilions. "The first of these - the SuperYacht Pavilion - was opened several years ago and we have been pleased to see it develop a very distinctive identity of its own while remaining very much part of the overall METS experience," adds Dros.

**An unmissable date with the SuperYacht Pavilion (SYP)**
While boat shows such as those in Monaco and Fort Lauderdale have traditionally been first on the calendar of companies in the large yacht industry, METS now attracts more suppliers in the sector than any other event worldwide. The SuperYacht Pavilion runs in association with the Global Superyacht Forum (GSF), one of the world's leading summits for captains, designers, builders, project managers, brokers and owners organised by SuperyachtEvents and hosted by The Superyacht Group.

Add in a wide range of educational and social networking programmes and it is clear why Amsterdam in November is now a must not just for the entire superyacht supply industry but also representatives from all the leading superyacht builders.

Professionals can visit for free after pre-registering online. Registration opens in August. More information can be found on www.metstrade.com or send an email to the organisers mets@rai.nl.




19,000+ visitor attendance
1,300+ exhibitors
5,000+ exhibitor staff
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175+ international journalists
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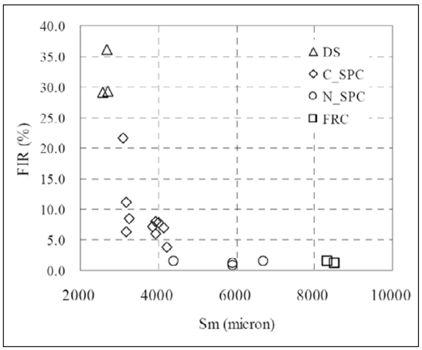


Figure 3: Relation between Sm and FIR

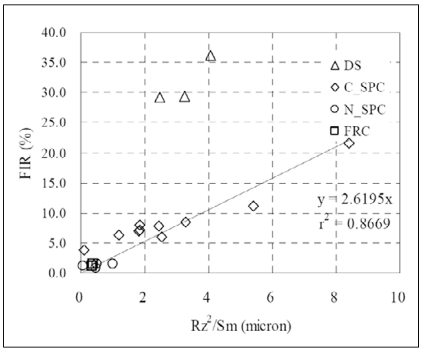


Figure 4: Relation between $Rz^2$/Sm and FIR

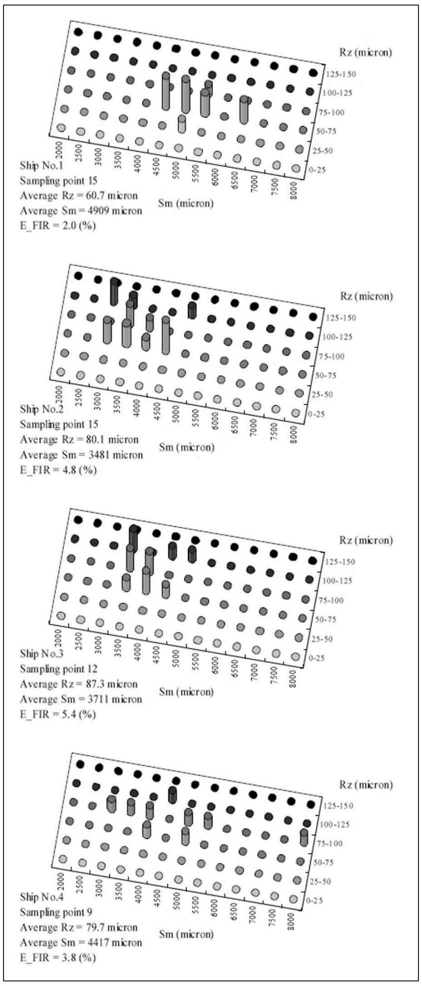


Figure 5:Distribution of Rz and Sm on actual

This actual vessel's result suggested that the friction of ship No.1 with N_SPC antifouling paint might be 1.8-3.4 % lower than that of the others.

## Conclusion

1) Relation between roughness parameters of various sprayed roughness and friction increasing ratio is confirmed in the Double Rotating Cylinder test.

2) Extremely short wave length roughness such as dry spray shows a 29-36% of friction increasing.

3) Silicone foul release coatings and new generation self-polishing coatings show lower roughness and longer wavelength because of their self-levelling property. They showed a lower friction increasing ratio than the conventional self-polishing coating.

4) Roughness parameter analysis was conducted on four newbuildings built in the same shipyard during more or less the same period. The new generation self-polishing coatings showed lower roughness and longer wavelength than conventional self-polishing coatings. The calculated friction increasing ratio is also lower.

5) Amplitude parameter and wavelength parameter are important tools for predicting the friction increasing that results from paint spraying. Some problems arising from this test such as measurement pitch and correction of film thickness were suggested. Further study is necessary to obtain more accurate results. The knowledge gained in this research is very useful for confirming the performance of newly painted hulls and the management method of ship hulls for achieving lower EEDI in the future. *NA*

Table 4: Roughness and E_FIR from actual hulls

| Ship | Coating | Rz range | Sm range | Rz average | Sm average | E-FIR |
|---|---|---|---|---|---|---|
| No.1 | N_SPC | 25 – 100 | 4500 – 6000 | 60.7 | 4909 | 2.0 |
| No.2 | C_SPC | 50 - 125 | 3000 – 5000 | 80.1 | 3481 | 4.8 |
| No.3 | C_SPC | 50 - 125 | 3500 – 5000 | 87.3 | 3711 | 5.4 |
| NO.4 | C_SPC | 50 - 125 | 3000 - 8000 | 79.7 | 4417 | 3.8 |

* *Reprinted from Conference proceedings, the Japan Society of Naval Architects and Ocean Engineers (14) 2012S-G2-17 (201205)*

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# Reworking the fatigue model

New fatigue models offer a key to the better utilisation of new materials and modern production technology in marine structures. Heikki Remes and Jani Romanoff of Aalto University, School of Engineering, Department of Applied Mechanics report

At present, the fatigue design methods used by classification societies are based on the average quality of the production. The same design recommendation and guidelines [1-2] are used both with traditional and more advanced structures.

However, through the development of manufacturing technology, it is possible to achieve characteristics that are significantly better than average. As results of the increased surface quality, the fatigue strength is significantly increased for both non-welded and welded material as shown in Figure 1A and B, respectively [3-6].

This allows for the better utilisation of the material and, as a consequence, lighter structures and more energy-efficient ships. However, the fatigue design basis for such advanced structures does not exist. Aalto University and Department of Applied Mechanics has been carrying out long-term efforts to develop scientific-based design methods for advanced ship structures.

In this article, one recently published model, microstructure- and strain-based fatigue approach, is discussed more thoroughly with respect to commonly used design methods. With the approach that has been developed, it is possible to consider the difference in the fatigue resistance between traditional and advanced, high quality, structural joints [7-8].

## Limited approaches

The fatigue strength modelling of welded joints is commonly based on nominal, structural stress or notch stress approaches. The fatigue strength of the joint is described by an S-N curve, where the total fatigue life is presented as a function of the specific reference stress range. The reference stress is obtained from the linear elastic analysis using the average weld geometry. Consequently, the statistical variation in the weld notch shape and the material properties are not considered and their effects on fatigue strength are included in the S-N curve.

For a joint welded using advanced welding methods, such as laser welding, the weld notch geometry can differ significantly from that of a traditional welded joint. Traditionally, a welded joint is assumed to incorporate crack-like defects and the crack propagation dominates the total fatigue life. For smooth weld notch geometry, the macro crack initiation becomes more significant.

A longer initiation time was observed to lead to a significant difference in the fatigue strength and slope value of the S-N curve in comparison to the existing S-N curves. This difference cannot be modelled with the existing stress-based approaches. The effect of crack propagation on the stress-strain state is considered in fracture mechanics - based approaches, but they require the initial crack. Therefore, these approaches neglect the crack initiation period.

## Strain - based crack growth approach

In the last few years, the strain-based approach has been developed further, to include the effect of the microstructure of the material on the stress - strain state and fatigue damage process. The continuum and strain-based crack growth approach that was developed was successfully applied to different weld metals [7]. In the recently published paper, the approach is further developed for welded joints [8]. There, the challenges are caused by the statistical variation in the weld notch geometry, the strength overmatching of the weld metal, and the arbitrary crack growth direction.

In the strain - based discrete crack growth approach, the fatigue damage process is modelled as a repeated crack initiation process within the volume related to the microstructure of the material, as illustrated in Figure 2. This volume is the damage zone where the micro cracks are assumed to nucleate and coalesce, causing macro crack growth. In the initial step, the initial joint geometry is applied without a crack. After the fracture of the initial damage zone, the crack is propagated until the critical crack size is reached. The total fatigue life for the final fracture is the sum of the load cycle number covering all the growth steps.

The novelty of the developed approach is that the size of damage zone is defined from the grain size statistics without the use of fracture mechanics. This enables consideration to be given to the changes in the stress gradient, stress triaxiality, and

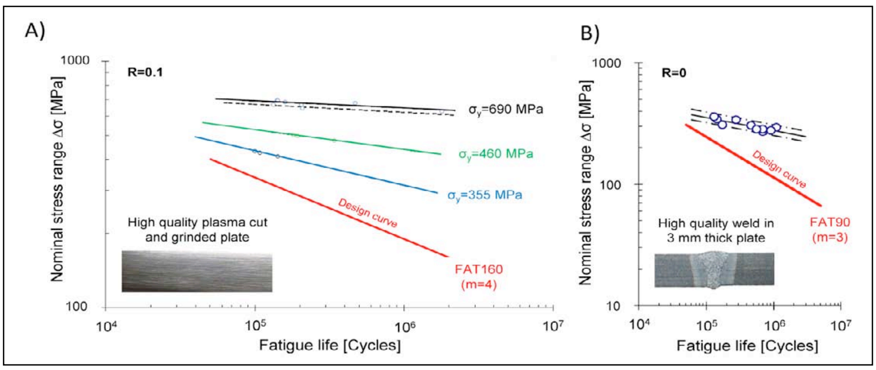


Figure 1: Comparison between the existing design curve and the fatigue strength of the advanced ship structures: post-cut treated corner of balcony opening (3) (left) and high-quality butt joint in thin plate (right) (4-5)

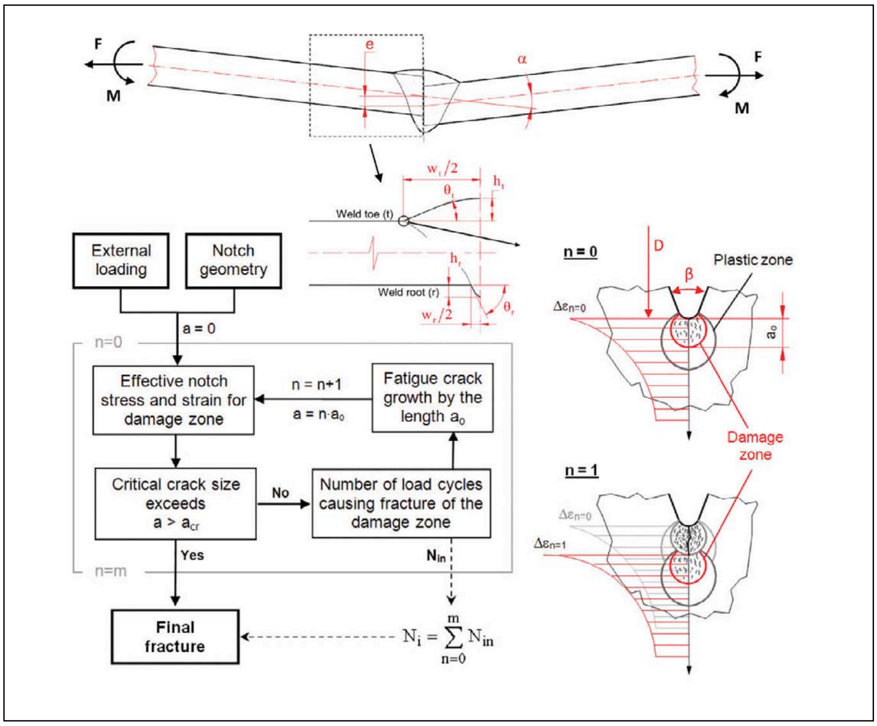


Figure 2: Flow chart of the fatigue damage modelling of welded joint (8).

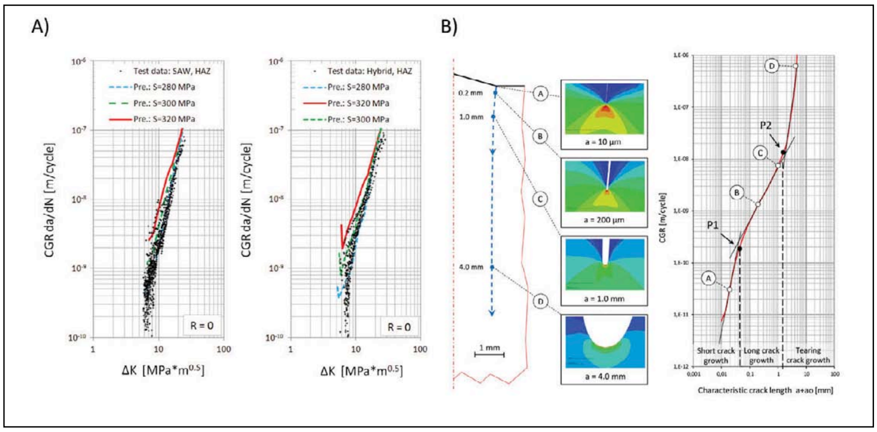


Figure 3: Comparison between the predicted and measure fatigue crack growth data (7), and the simulated fatigue crack growth rate (CGR) for high quality weld (8).

plasticity during the fatigue crack initiation and growth. Consequently, the approach enables the fatigue crack growth simulation starting from the actual weld geometry.

The developed approach has been validated with experiments on submerged-arc-welded, and laser-hybrid welded joints, see Figure 3. The predicted fatigue strength, crack growth path and crack growth rate showed good agreement with the experiments. A welded joint with a smooth notch shape, has a short crack growth period and this has a significant influence on the fatigue life. For the laser-hybrid joint with a smaller grain size, the short crack growth started earlier, but it took a longer time than that of the submerged-arc-welded joint with a larger grain size.

Therefore, the present study indicates that for a smooth weld shape the consideration of the microstructure of the material is required to have sufficient fatigue strength modelling. In the case of a deep weld notch, the short crack growth was insignificant and consequently the influence of the material microstructure vanished. *NA*

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# Paying the piper

Didier Vassal, vice president OEM and Maritime Services at Victaulic explains the advantages that grooved pipe joints provide over flanges.

Efficient piping systems are essential for the range of services needed on board a vessel including secondary systems such as bilge and ballast systems, sea and fresh water cooling, lube oil, fire protection and deck wash.

For these systems, where piping class permits, an effective pipe-joining alternative to welding/flanging is the use of grooved mechanical joints which offer a range of technical, economic and practical benefits. These include enhanced performance; faster, simpler installation and maintenance; and weight reduction.

## Performance issues

In a flanged pipe joint, two mating flanges are bolted together and compress a gasket to create a seal. As the bolts and nuts of a flanged joint absorb and compensate for system forces, over time they can stretch and lose their original tightness due to pressure surges, system working pressure, vibration, and thermal expansion and contraction. When these bolts experience torque relaxation, the gasket will lose its compressive seal, which can result in varying degrees of leakage.

Depending on the location and function of the piping system, leaks can be costly and hazardous, resulting in maintenance/repair downtime and exposure to risk. Gasket replacement will be required when the joint is taken apart, as the gasket will bond to the flange faces during the course of time. When the joint is disassembled, the gasket needs to be scraped from both flange faces and these surfaces cleaned before the gasket is replaced, again increasing maintenance downtime. Due to the bolting forces, along with system expansion and contraction, flange gaskets can also develop compression "set" over time, presenting another cause of leakage.

The design of a grooved mechanical pipe joint (shown in figure 1) overcomes these performance issues. A groove is first formed in the pipe end and the piping connection is secured by a coupling which houses a resilient, pressure-responsive elastomer gasket. The coupling housing fully encloses the gasket, reinforcing the seal and securing it in position as the coupling engages and forms a positive interlock into the pipe groove.

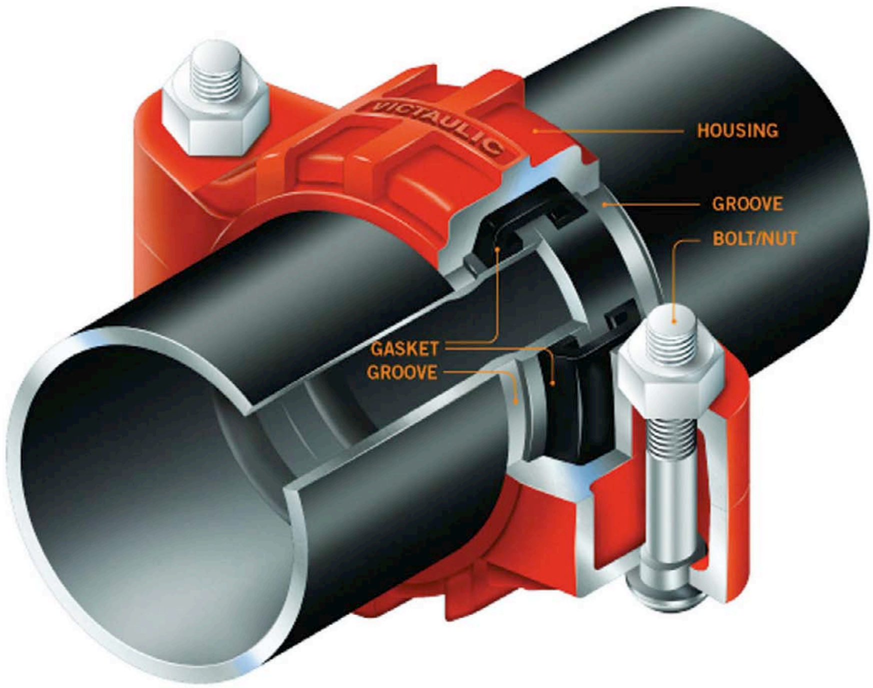



Figure 1: Anatomy of a grooved connection

The mechanical joint creates a triple seal due to the design relationship between the pipe, gasket and housings, which is enhanced when the system is pressurised.

## Rigid and flexible couplings

Available in both rigid and flexible forms, grooved mechanical pipe couplings are class society type-approved, and may be used instead of welded/flanged methods, subject to installation criteria established by each certifying agency.

Rigid couplings are used, for example, around areas such as manifolds and valves, where they offer easier access and replacement than flanges. By nature of their design, rigid couplings also provide axial and radial rigidity comparable to flanged or welded joints.

Flexible couplings have advantages in applications where relative movement between the pipe and supporting structure is anticipated, in addition to pipe movement resulting from thermal expansion or vibration. Expansion and contraction can stress the flange and piping, which can compromise the gasket over time. When this occurs, the joint is at risk of leaking. Grooved flexible couplings can accommodate pipe displacement in the form of axial movement or angular deflection. (See figure 2)

## Ease of installation

On initial installation, bolt holes of a flange must be precisely aligned then tightened to hold the joint. The bolt-hole index on equipment inlets and outlets must also line up perfectly with the flange on the piping to be connected to the unit. With only one of a number of fixed positions determined by the number of holes in a flange, a fitting or valve can only be rotated to match the bolt holes. The opposite end of the flanged pipe must also line up with its mating flange, which further increases assembly difficulty and the risk of misalignment.

Grooved piping systems allow much more convenient installation, with a full 360degs rotation available for the pipe and mating components. There is no bolt-hole pattern to line up, and a coupling can be oriented at any position around the joint. The coupling can be rotated around the pipe to provide easy access to the bolts and simplify access to the equipment.

In addition to eliminating misalignment during installation, a coupling's 360degs orientation capabilities, together with its smaller profile compared to a flange, make the installation of grooved systems ideal for confined spaces. The installer can orient all of the assembly bolts on each joint in the same position to ease system inspection and maintenance.

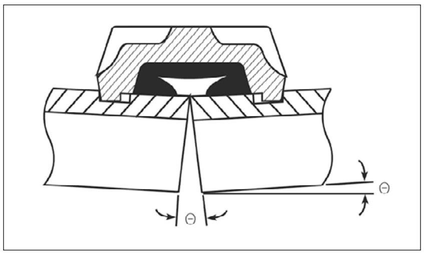


Figure 2: Flexible couplings allow for angular movement

Flanges are roughly twice the outside diameter of the pipe they are attached to. On average, grooved couplings are only half this size. The size advantage of the smaller design makes the grooved system ideal for jobs where space is limited, such as deck and wall penetrations.

## Speed of assembly

Because couplings have fewer bolts and no torque requirements up to 300mm (12"), grooved piping is much faster to install than flanging. Unlike flanges that must be welded to the pipe end, grooved valve assemblies do not require welding, which further cuts installation time and avoids potential heat damage to the valve while also reducing safety risks by eliminating hot works.

A comparison of a DIN 150 ballast line installed using Victaulic grooved products versus traditional joining methods showed a 66% reduction in total installation time required (150.47 man hours versus 443.16 man hours). The time needed to install 52 slip-on flanges and weld elbows and tees compared with 60 rigid couplings showed the largest time differences.

In addition, flanges require time-consuming star pattern tightening with specialised wrenches to measure and ensure that correct torque specifications are achieved. Grooved pipe technology allows couplings to be assembled using standard hand tools and the joint is properly installed once the mating bolt pads of the coupling housings meet metal-to-metal. A simple visual inspection confirms correct assembly. Flanges, on the other hand, do not provide visual confirmation: the only measure to ensure proper assembly is to fill and pressurise the system, check for leaks and retighten the joints as needed.

## Maintainability

The same characteristics of grooved piping systems that accelerate installation—fewer bolts and no torque requirements — also make system maintenance or alteration a quick and simple task. To gain access to a pump or valve, for example, the two bolts of the coupling are loosened, and the housings and gasket removed from the joint. In a flanged system, multiple bolts need to be removed. The same time-consuming bolt-tightening sequence required upon initial installation is also required upon reassembly of the flange.

Because they do not require retightening, couplings eliminate much of the routine maintenance associated with flanges. Unlike a flange that puts variable stress on the gasket, nuts and bolts, a coupling holds the gasket in precise compression from the outside of the pipe joint. Additionally, since coupling gaskets are not subjected to high compressive forces, they do not need to be replaced on a regular maintenance schedule, while flange gaskets need to be replaced when the system is disassembled for maintenance.

## Weight reduction

Valve assemblies are typically constructed with flanged components. However, this joining method can add unnecessary weight to a piping system. A 150mm (6") flanged valve assembly constructed with a lug butterfly valve, connected with weld-neck flanges and eight bolts and nuts on each side of the valve, weighs approximately 39kg. A 150mm (6") valve assembly that utilises a grooved-end butterfly valve, grooved-end pipe and two rigid couplings to connect the components weighs approximately 16kg, representing a 58% weight reduction over the flanged assembly.

The above-mentioned comparison of a DIN 150 ballast line showed a weight reduction of 30% (982.43kg compared to 1412.58kg) when grooved products were used instead of traditional joining methods. The 52 slip-on flanges, bolt sets and gaskets, versus 60 rigid couplings accounted for major weight increases in the welded/flanged system.

Weight reductions by using grooved pipe couplings instead of flanges are achievable across a range of pipe sizes. The magnitude of the reduction depends on the pipe diameter and type of coupling used. In tests where piping was connected using one Victaulic Style 77 coupling – the heaviest coupling in the range – compared with two light-weight PN10 slip-on flanges, the total installed weight of the grooved assemblies was significantly lower. Weight reductions were recorded as follows: 100mm (4") – 67%; 300mm (12") – 54%; 500mm (20") – 60.5%.

With lighter-weight flexible or rigid couplings and/or a heavier type of flange, weight reductions of 70% are achievable. Shipyards that have used grooved couplings in preference to flanges on selected systems have recorded weight savings of 12tonnes on offshore support vessels and 44tonnes on cruise ships. *NA*

## Noise and Vibration Attenuation

**To attenuate system noise and vibration, flanged systems require rubber bellows or braided flexible hoses. These items can fail due to overextension and, with normal wear, need to be replaced every 10 years on average, incurring cost and system downtime.**

**Mechanical grooved pipe couplings, however, last the life of the system. Their ability to accommodate system vibration reduces the risk of joint failure, without the need for speciality products that require periodic repair or replacement. The resilient elastomeric gasket contained within both flexible and rigid couplings is very durable and can handle significant operating pressures and cyclical loading. A system can be pressurised and depressurised repeatedly without fatiguing the elastomer gasket.**

**Independent tests have demonstrated that couplings are most effective at reducing noise and vibration. NUTECH Testing Corporation/SE Laboratories Inc. applied a vertical acceleration to one end of a pipe assembly, measured the responses and compared the performance of couplings and elastomeric flexible arch connectors. The results showed that Victaulic couplings displayed the best vibration solation/attenuation characteristics (Figure 3).**

**The best arrangement is to place three flexible couplings close to the source of vibration. For any given pipe diameter, the use of additional Victaulic couplings - whether flexible or rigid - in the system will further reduce the transmission of vibration.**

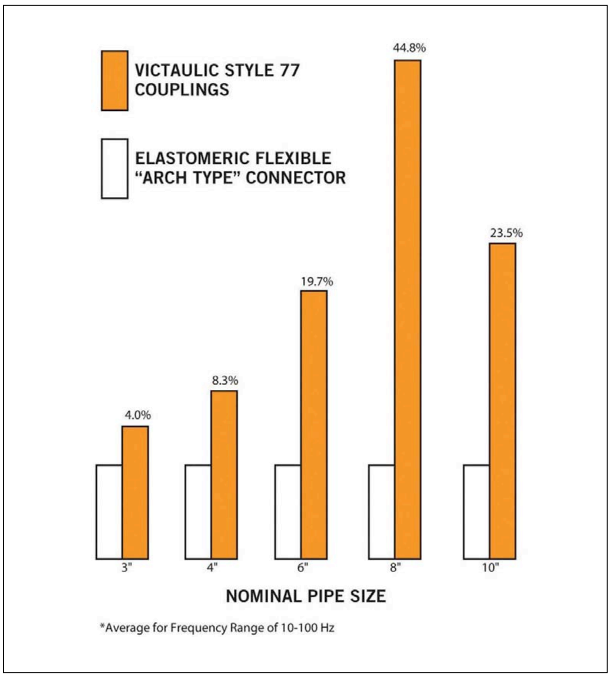



Figure 3: Percentage of additional decrease in sound provided by three grooved mechanical couplings.

# The dampening effect

## Dutch-based vibration company Loggers takes a different approach to abating noise and vibration on ships

Higher productivity demands, compliance with working and safety regulations and environmental awareness means that vibration and noise control are taken seriously throughout the shipbuilding industry.

Vibration and noise have a major negative impact on all the systems onboard, the crew, the environment and the ship itself. For this reason many engineers apply vibration isolators, especially when mounting the most notorious source of onboard vibrations and noise: rotating equipment.

When done properly, the application of vibration isolators can extend the lifetime of the equipment, lower maintenance costs and significantly improve working and living conditions onboard. But, the selection of the right vibration mounts sometimes might seem complex as many factors need to be taken into account.

"Clients are often surprised by the level of detail of the information we request when determining what vibration isolators to use for their application", Ronald van de Vliert, technical manager at Loggers explains. "However, the quality of the eventual solution strongly depends on the quality of this input. It is impossible to achieve the optimal result when the selection is based on mere assumptions regarding the equipment and its operating conditions."

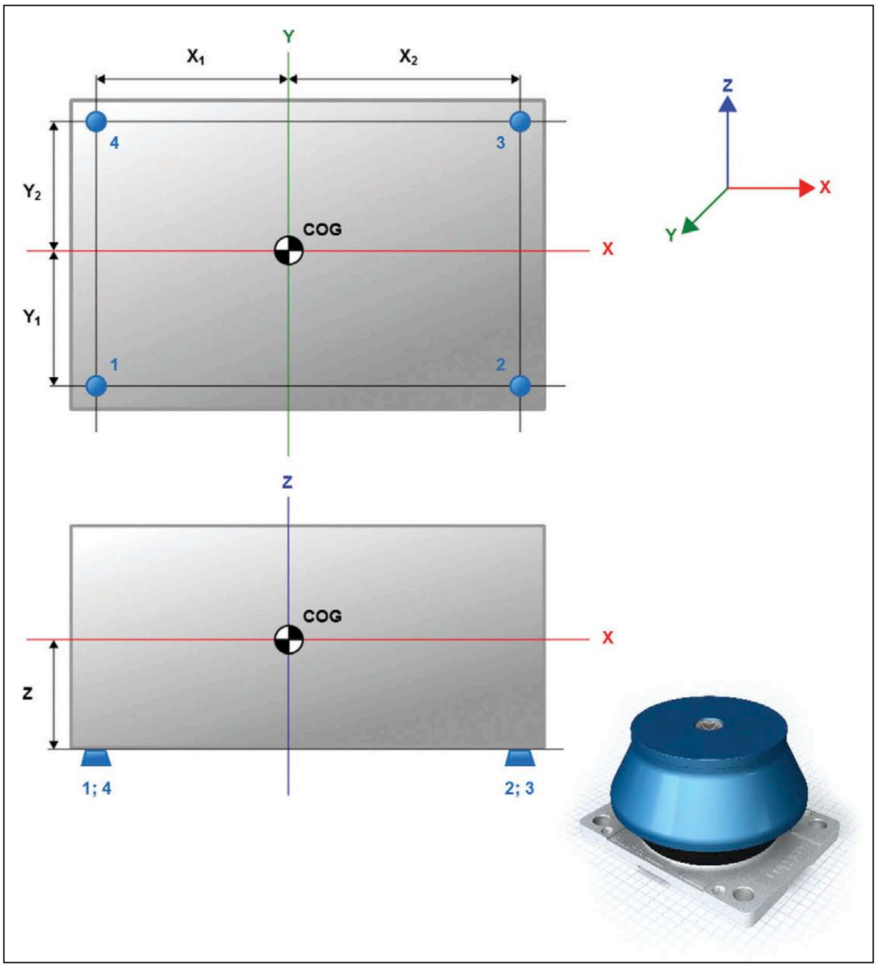



Figure 1: Schematic representation of a typical four point setup used for the selection of vibration isolators

The selection method Loggers uses to illustrate this, applies to four-point setups widespread throughout the maritime industry. This relatively simple selection method for four-point setups proved itself time after time. Typical applications that often require this type of set-up, are smaller (auxiliary) engines, generator sets and pumps. This "how-to" can be performed with basic knowledge of specific maritime conditions, common physical formulas and technical information of vibration isolators and the equipment to be mounted.

The method consists of five steps and results in the selection of the optimal vibration isolators for your specific application that provide the highest level of isolation. It is part of the framework that Loggers' engineers use when developing solutions for clients worldwide: Loggers' Solution Development Methodology. For readability, the formulas used have been omitted in the description of this article, but these can be easily found in other literature on this subject. Vibration isolator selection is of great importance for both the Engineering & Design and Calculation & Simulation phases of this methodology, as its outcome determines the direction of the eventual solution for the client, says the company.

### Gathering information

The first step is considered the most important, as the quality of the input determines the quality of the output. Examining the equipment's technical documentation carefully and to take note of the following parameters: weight, dimensions, rotational speed, the location of the centre of gravity (COG) and mounting positions of the vibration isolators. In the ship's design specification and drawings, look for the maximum allowed roll & pitch values and the direction in which the equipment is mounted, e.g. longitudinal or lateral.

For example, the outcome of the first step should contain the following information in order to select the optimal vibration isolators: The auxiliary engine that needs to be mounted in a longitudinal direction has a mass of approximately 5,250kg. The distance in between the mounting positions is 1.88m in length and 1.24m in width. The engine typically runs at 1,800rpm. Its COG is located out of the engine's geometric centre at 0.86m of its length (X), 0.63m of its width (Y) and 0.53m high (Z). The engine will be used on the high seas with relatively high maximum roll and pitch values of respectively 22.5 and 10degs.

All this information is needed to determine the most optimal vibration isolators for this application in the next four steps. Of course, any assumptions should be precisely documented for future reference.

## Determination of the point load

The point load is defined by the way in which the equipment's weight is distributed over the mounting positions. The load per mounting position may differ, as this depends on the centre of gravity of the equipment. On the rare occasion that the COG is located right in the middle of the equipment, one could suffice by evenly distributing the load over the four mounting positions. In practice, this hardly ever occurs as the COG of the equipment usually is not located in the exact centre of the equipment. The point load needs to be relatively determined instead using the location of the COG in X and Y directions.

In the case of the example data "gathered" in the first step, the relative distribution of the gravitational force (Fz) in vertical direction over the four mounting positions leads to the following point loads:

Position 1: 1,401kg
Position 2: 1,181kg
Position 3: 1,220kg
Position 4: 1,447kg

## Pre-selection of the vibration isolator(s)

The effectiveness of vibration isolators is defined by some basic physical rules. Revolutions and vibrations are in fact the same. For this reason, the main vibration source of the equipment is converted to the common unit of measure for frequencies, Hertz (Hz). This value is often referred to as the main disturbance frequency. Another important type of frequency is the natural frequency. This frequency is determined by a common physical formula, in which the isolator's spring constant and the equipment's mass are the main parameters. Both types of frequencies play an important role in the (pre-) selection of vibration isolators.

The disturbance frequency of the engine used in the example is 30Hz (1,800rpm). A common rule of thumb is that the natural frequency of the isolator should be at least half of the disturbance frequency, in order to provide adequate vibration isolation. Rubber based vibration isolators typically start isolating frequencies from 9Hz and up, which makes them the isolators of choice for the application example.

With the point load values determined in the previous step, it is possible to make a tentative selection of the appropriate vibration isolators. This is done by comparing the point load with the maximum marine load of the vibration mount, one of the specific characteristics of vibration isolators. This limit is basically a safety threshold used for pre-selection of vibration mounts that need to be capable of taking up the ship's movements. When looking up the load values, multiple isolators might qualify. As vibration isolation capabilities increase with the level of compression, the vibration mount with the highest compression under the maximum marine load limit is generally considered the most effective.

When looking up the vibration mounts for our example setup in the vertical characteristics graph of Loggers' Evolo datasheets, the Evolo 631 grade F would seem the optimal choice for all four mounting positions. In this specific case, these isolators provide the highest compression whilst not exceeding the maximum static marine load limit. However, the eventual selection might differ as this is a tentative selection of vibration isolators. Their behaviour under maximum roll and pitch conditions still need to be verified and might exceed the maximum static marine load when the roll and pitch values are relatively high.

## Roll and pitch

Although the maximum marine load was paid attention to, in the pre-selection, this does not ensure safe operation yet. To safeguard that the equipment will withstand the conditions at sea, it is necessary to verify that the forces the isolators are exposed to during roll and pitch, do not exceed the maximum static load of the isolator excessively. This is where the COG comes in again. A higher COG (in Z direction) will lead to higher load, in some cases tensional, of the vibration mounts during the ship's operation. To make sure that they are not overloaded or get torn by the forces induced by ship movements, the point loads during maximum roll and pitch values need to be calculated.

The maximum roll and pitch values in the example setup each have their effect on the load distribution on the isolators in both vertical and horizontal directions. As the engine is placed in a longitudinal direction in relation to the vessel, the point load induced by roll movements and corresponding deflection are calculated for the isolator pair at position 1 and 4 as these mounts are exposed to the highest loads. For pitch movements, the highest load and deflection are calculated for the pair at position 1 and 2. The calculated impact in vertical direction caused by maximum roll and pitch at 22.5 degs of roll the loads would be 2,663kg at position 1 and 182kg at position 4 or vice versa. At 10degs of pitch the loads inflicted on position 1 are 1,314kg and 1,273kg at position 2, or vice versa.

Verification that the point load during roll and pitch conditions does not exceed the maximum load of the vibration isolator and is capable of absorbing the deflection is required for safe operation. If the selected isolator does not qualify a vibration mount with less compression should be selected.

Another important factor to be taken into account is the angular displacement during roll and pitch, as high values will cause excessive wagging of the mounted equipment. This could mean that some vibration isolation needs to be sacrificed to ensure safe operation at sea, in order to achieve an end result that is both satisfactory and safe. Alternatively, this can also be overcome by the use of stabilisation vibration mounts at the top the equipment.

With the effects of maximum roll and pitch on the setup now determined, the initial selection of Evolo 631 Grade F vibration isolators prove unusable for this specific application at sea. On land these mounts would function perfectly, but the forces inflicted by sea motion on the four positions require stiffer isolators to prevent isolator overload and wagging of the equipment. In most cases, the angular rotation should not exceed 0.25degs. For this reason, a pair of Evolo 631 Grade B are selected for the most heavily loaded positions 1 and 4, and a pair of Grade C isolators for the other two positions. By combining isolators with different stiffness, the optimal result is achieved.

## Verification through calculation

The effectiveness of the selected vibration isolators can be verified and expressed by calculating the frequency ratio and degree of vibration isolation. The frequency ratio expresses the disturbance frequency in relation to the equipment's natural frequency. With this ratio the degree of isolation is calculated, resulting in a percentage that illustrates the level of vibration reduction. This value is often used for comparison of various isolation alternatives.

The disturbance frequency of the engine used in the example is 30Hz (1,800rpm). The selected isolators for the setup result in a natural frequency of 7,8Hz in vertical direction. The achieved percentage of 93%, however, can be interpreted by a wider audience than when providing just these frequency values.

## The result

The vibration mounts that were selected and verified in the five steps of this method, can be considered the most effective as it provides optimal vibration isolation whilst meeting the requirements for safe operation during maximum roll and pitch movements of the vessel. However, a vibration mount is not the only connection between the equipment and the vessel. In order to decouple the equipment completely from its environment all other connections need to be examined as well, such as pipelines for fuel and exhaust gases. When these connections are rigid, vibrations are still transmitted to the vessel, diminishing the results achieved with the selected vibration mounts. A proper setup of the equipment therefore often also involves the use of expansion joints that connect pipelines to engines and pumps in a flexible manner.

> "We have advanced calculation software and simulation models at hand that assist us in the selection of the right vibration isolator"

The selection process for the appropriate expansion joint is based on a different method that also makes sure that the expansion joint can compensate not only the vibrations, but also the equipment's displacement and thermal expansion and contraction in the pipeline itself.

## More complex challenges

The four point setup is a relatively simple setup. Complexity increases with the number of mounting positions, in particular the determination of the point loads at each mounting position. The impact of ship motion on these loads and the presence of more vibration sources affecting the equipment add even more complexity. Amongst others, one of the typical checks performed is the resonance check. With a 6 degrees-of-freedom calculation the natural frequencies in X, Y and Z direction (translational and rotational) are defined. For each specific situation it is then verified whether disturbance frequencies originating from the equipment or its environment could cause resonance problems. Resonance is to be avoided at all times, because it causes significant nuisance and even might damage the equipment.

"For more complex setups or when clients are not sure about what isolators to use, Loggers' vibration specialists are more than happy to pick up the challenge. We have advanced calculation software and simulation models at hand that assist us in the selection of the right vibration isolator and predicting the solution's behaviour onboard," says Ronald. "For this reason, renowned Original Equipment Manufacturers (OEM) have entrusted the whole calculation and selection process to us. They have discovered the benefits of outsourcing and recognise the importance of close cooperation."

Adhering to the described method guarantees correct dampening of vibrations and therefore minimising the impact vibrations have on the crew, the equipment and the ship itself. It leads to effective vibration isolation solutions by which higher productivity and compliance with working and safety regulations are achieved. With the vibration challenges solved, the ship's engineers, crew and owner can now refocus on their core activities. *NA*

# Europe funds research into efficient shipbuilding materials

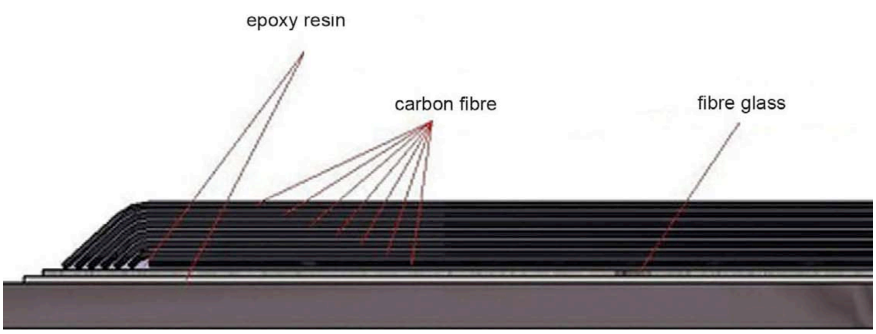
MOSAIC project set to research the integration of composite materials and high-strength steel in an effort to develop sustainable shipbuilding for the future. The MOSAIC team outline the project's aims

Some of the leading European research institutions, shipbuilders, universities, shipping companies and classification societies, specialised in studies on materials and marine structures, are working together to help the shipbuilding industry advance towards more environmentally friendly, cost efficient and safer ships.

They have joined their forces in a new collaborative research project MOSAIC (Materials On-board: Steel Advancements and Integrated Composites), co-funded by the European Commission under the 7th Framework Programme.

The project aims to investigate two novel ideas concerning ship structures:

- The introduction of High Strength Low Alloyed Steels (HSLA) in specific structural details in order to deal with the issue of crack initiation and propagation in critical areas of the ship and
- The replacement of specific structural parts of the ship (superstructures, transverse bulkheads, partial decks, etc.) with Composite materials (such as GRP) to reduce weight and corrosion.




Carbon fibre fabric layup

The ultimate goal of the application of these technologies in ship structures is to:

- improve the structural response of the ship
- minimise corrosion and structural defects
- reduce the lightship weight of the structure
- reduce the maintenance and overall operation cost of the vessel
- reduce fuel consumption.

Mosaic is a part of the European Commission`s co-funded initiative with a budget of around €4,1 million (US$5.44 million). The project started in September 2012 and will continue with its research and development until September, 2015. It gathers 11 partners from six European countries, led by the Italian research centre CETENA, SpA.

The European dimension of the project is also supported by the geographical distribution of partners (Italy, Portugal, Spain, United Kingdom, Greece and Croatia), well distributed around the Mediterranean and the Atlantic zone.

Besides the coordinator, other partners on the project are, as follows:

- AIMEN Technological Centre, Spain
- as2con - alveus Ltd., Croatia
- The University of Birmingham, UK
- Danaos Shipping Co Ltd., Cyprus
- Estaleiros Navais de Peniche S.A., Portugal
- Fincantieri Cantieri Navali Italiani (FINCANTIERI) S.p.A., Italy

*Carnival Breeze* under construction at Fincantieri shipyard

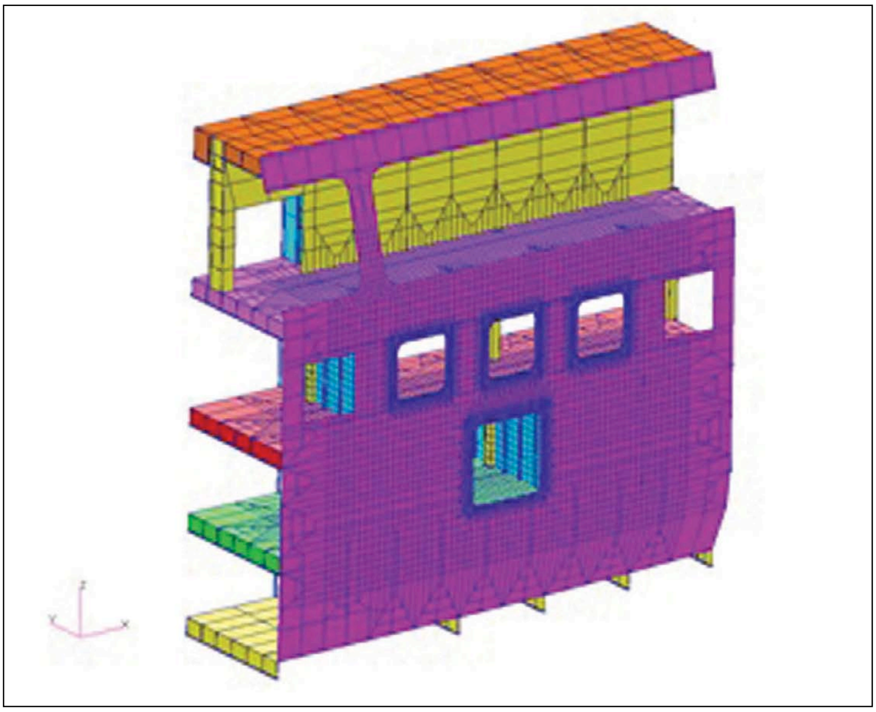
- Instituto Superior Tecnico (IST), Portugal
- Lloyd`s Register, UK
- National Technical University of Athens, Greece
- TWI Ltd, The Welding Institute, UK

## Problems addressed

Today's merchant and passenger vessels, such as tankers, bulk carriers, container ships, cruise ships and ferries are complex structures that operate in harsh environments with respect to corrosion and cyclical loads. These ships are built using marine steels in order to meet the structural requirements for accommodating loads exerted by the marine environment and from operations. These loads, in conjunction with the highly corrosive environment, lead to the development of local defects, which, in combination with the ship's light weight and with corrosion, affect the ship`s operational and maintenance costs.

These three key issues are at the forefront of the current marine research and here is why:

- Reducing the overall weight of a ship can reduce fuel consumption which can be translated to reduce engine emissions and also increased payload at a given design displacement. Reduced fuel consumption entails lower ship's operational costs and higher payload value per single voyage.
- Corrosion, especially in the marine environment, leads to material wastage, increased maintenance costs and, on special occasions, to defects that can compromise the structural integrity of a ship.
- Structural defects developing at stress concentration areas pose a threat to the structural integrity of any vessel. Rectification actions include the replacement of the cracked plates and/or stiffeners with thicker parts and the introduction of brackets or stiffeners. The direct result of these actions is frequent maintenance and repairs, material wastage, increased weight and increased ship down times. In addition, for passenger ships and ferries, it is also very important to note the impact on aesthetic and architectural design choices.



FE Model of a ship's structure

## Why HSLA steels

HSLA steels are essentially a category of steels that can be tailored to offer increased mechanical properties such as high fracture toughness properties, improved response to cyclical loads, high strength and welding corrosion resistance. In addition, HSLA steels can offer improved welding properties and strength by controlling the formation of microstructure, carbon content and alloying elements. In a complementary note, Friction Stir Welding (FSW) can be also assessed for HSLA welding and HSLA to marine steel welding.

## Why composites

Composite materials, due to their basic advantages of low weight and non-corroding nature, are envisaged to be used in certain parts of the ship, such as superstructures, transverse bulkheads, non-structural decks, etc. By using composite materials to replace the corresponding steel parts, the overall weight of the ship is reduced, with the added benefit of improved corrosion resistance.

MOSAIC intends to use composite materials wherever possible, not only from a regulatory point of view, but also considering the constraints imposed by the shipyard environment.

## Organisation of work

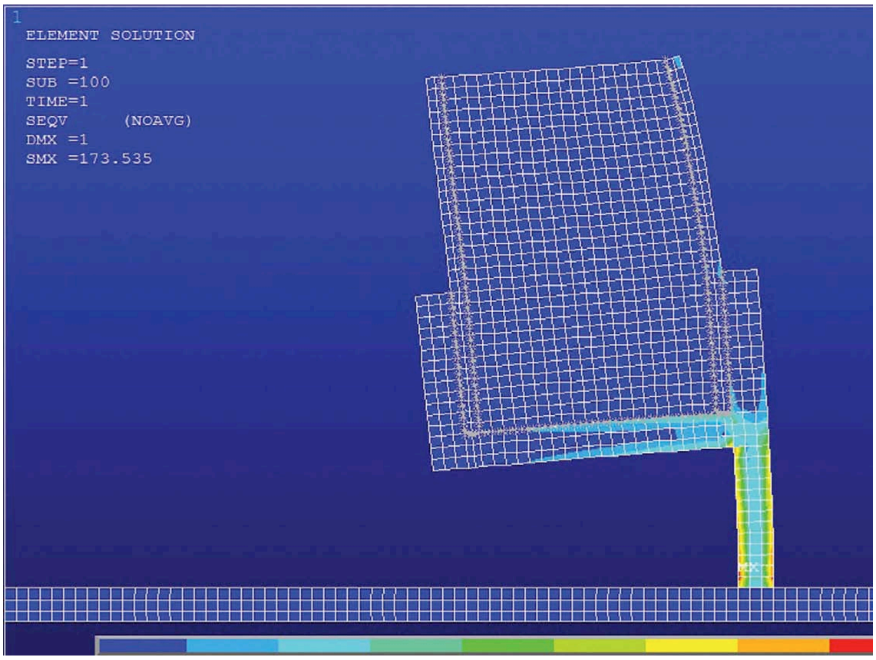
All activities in the project are divided into eight work packages, six of which are purely technical, one oriented to the dissemination and exploitation of results and one dedicated to administration and coordination of the project.
They include:

1. Specification of application cases and operational requirements
The aim of this work package is to define ship details where defects are most frequently developed (critical zone in terms of fatigue, corrosion, etc.) in order to identify the application cases in which to replace marine steels with HSLA steels and structural parts of the ship with composite materials.

2. Material selection and characterisation

The aim is to provide a selection, characterisation and modelling of the materials involved in the project.

- For HSLA, an identification of microstructural features, alloying




Numerical modelling of a steel composite joint

elements, manufacturing processes that enhance or retard crack initiation and growth in relation to loads exerted by day to day ship operations are foreseen
- For composite materials, an identification of properties that can meet the structural and operational requirements of the ship steel parts that they will replace, are foreseen.

3. Small-scale testing

This work package is dedicated to small-scale testing regarding joining techniques for integration of HSLA steel details and composite components on board. The activities are aimed to design and test welded joints and hybrid composite/steel joints.

4. Onboard integration and design of the innovative solutions

Best practice about material behaviour and joint design modelling will be used in order to evaluate global/local structural strength of the onboard integration of innovative solutions. Also, extensive finite element modelling will be performed, aiming at defining procedures for the passage from the coarse mesh to fine mesh model that incorporates HSLA structural details and composite replacements.

5. Large-scale tests

In this work package, large scale tests have been planned, dedicated to different HSLA structural details and composite replacements. Large scale sub-assemblies for HSLA steel and composite replacements will be manufactured and tested in static/fatigue loading conditions as well as validated by numerical models.

6. Life cycle cost assessment and business plan implementation

This package includes the following activities:
- Life Cycle Cost assessment - to prove the sustainability of concepts studied in the project
- Development of a business plan for the proposed technology - including cost-benefit analysis, market research and definition of appropriate marketing strategies
- Development of guidelines for the on board integration of HSLA steel details and composite replacements.

7. Dissemination and exploitation

The main objectives of this package are:
- To disseminate the project results, making them well known to all relevant stakeholders (shipbuilders, shipowners, operators, class societies, insurers, charterers, designers, port, and research and technology providers including academia),
- To foster the exploitation of the project results to the benefit of the MOSAIC partners
- To improve the competitiveness of the EC shipbuilding, shiprepairing and construction sector.

8. Coordination and management

## Technical work done so far

In the initial phase of the project, application cases were defined starting from an analysis of more than forty critical structural details.

Some of them include:
- Balcony openings of a cruise vessel
- Misaligned plates and knuckled hoppers
- Double bottom floors/girders lightening openings
- Bow enclosure and etc.

Characterisation of HSLA and composite materials together with testing of specimens and is currently under development parallel with identification of best joining methods for both technologies with special emphasis on steel to composite joints.

The developments and results of the project will be available on the official project webpage *www.mosaicships.com*. *NA*

## Authors:

Tanja Pavlović, Carlo Cau and Marko Katalinić.

## References:

The contact email for the project the project is *info@mosaicships.com*

Project website of the project and official info about the project on EC webpage
*www.mosaicships.com*
*http://cordis.europa.eu/projects/rcn/104600_en.html*

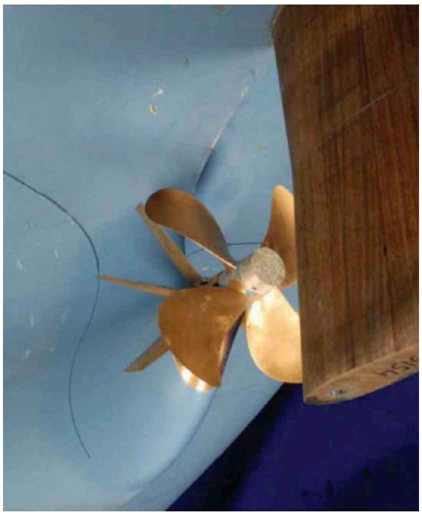
# Energy saving devices tested

With environmental concerns becoming the most important issues facing the shipping/shipbuilding industry today, SSPA has witnessed strong demand for the development of energy saving devices (ESD). Keunjae Kim, Ph.D, project manager, SSPA explains further

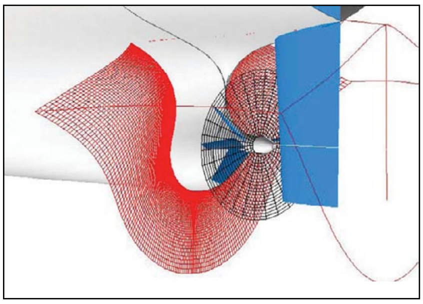
SSPA envisions that demand for energy saving devices will be greater in response to the new requirements as set out by the IMO through its Energy Efficiency Design Index (EEDI). Most energy saving devices (ESDs) are used to enhance the flow into propeller, aimed at increasing propulsion efficiency as well as reducing energy loss.

The design of ESDs requires knowledge of the flow mechanism around the ESD and highly advanced CFD simulation coupled to accurate model testing. SSPA has been involved in many joint research projects in developing energy saving solutions. This article is a short summary of one of the most successful ESD developments.

Various energy saving devices can be applied, but the practically applicable devices should be simple, relatively cheap to install, easy to maintain and most importantly, the ESD design should have a solid scientific background. Daewoo Shipbuilding and Marine Engineering Co. Ltd (DSME) has developed its pre-swirl stator (PSS) in cooperation with SSPA; SSPA tested most of DSME's designed PSSs over the past 10 years. The PSS is a device mounted on the boss end of the hull in front of the propeller (see illustrations above right) and is designed to generate pre-swirl flows in order to gain a favourable interaction with the propeller action that improve the propulsive efficiency, thereby reducing power consumption.



PSS mounted on ship model for testing computation



PSS model set-up for CFD

## The four blades approach

Three to six blades have been investigated in various configurations on single screw ships over the years and the stator configuration selected from the optimisation investigation typically has four blades with a diameter equal to the propeller diameter. This has become the standard configuration for a wide range of hull types including VLCCs, tankers, bulkers, ro-ro and container ships. The DSME PSS has been successfully applied to various ship types, with an average gain of 4% on propulsion power achieved in model tests and confirmed in sea trials.

## The configuration process

The optimum configuration of a PSS is determined by CFD computations and tank tests. A wide range of design parameter variation studies were performed first by SHIPFLOW computation and the most promising configurations were selected for the final confirmation by model tests.

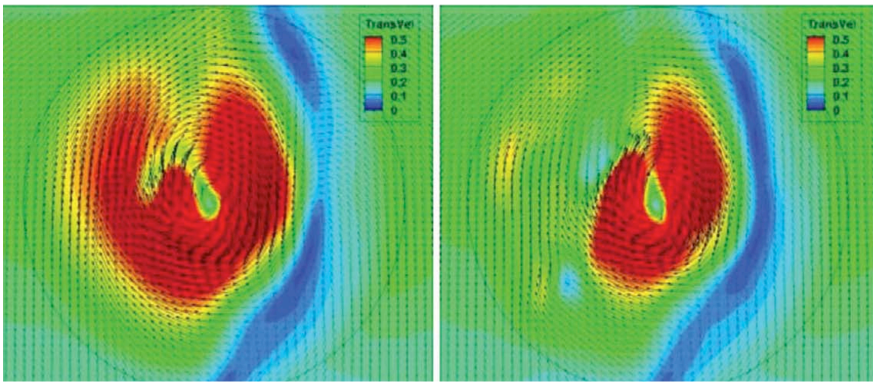
This type of CFD computation is a very challenging task as this requires full simulation of proof-of-work (POW), resistance and self-propulsion tests with a high level of accuracy that is capable of predicting small differences in flow characteristics, as well as the relative ranking of propulsion efficiency due to the small variation of a design parameter setting of PSS.

Extensive internal SSPA research work has been performed in this area in 2009-2010 to investigate the limit of SHIPFLOW prediction accuracy for self-propulsion test simulations. Promising results were obtained for a container vessel and a VLCC. The coupling between the potential-flow based method and RANS code proved to be a sufficiently complete and accurate approach for predicting the thrust, torque and rotation rate for the propeller, in order to achieve the correct ranking between different design alternatives.

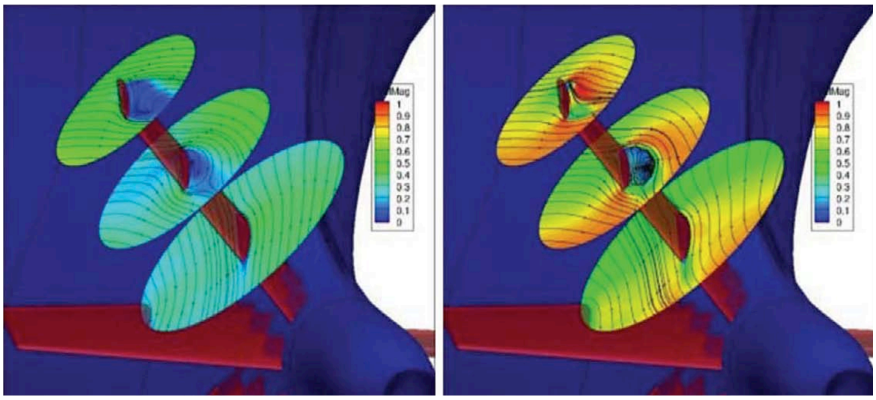
The computer generated picture (left) illustrates the calculation model set-up for SHIPFLOW computation; the overlapping grid technique with structured components was used to achieve high quality cells for the background hull and appendages. The overlapping grids consists of one back ground grid with an additional refinement covering the stern of the ship and six component grids for four pre-swirl stator blades, one propeller and one rudder.

## The SHIPFLOW part of the process

SHIPFLOW simulation was carried out in two steps: In the first step, a base



Transverse velocity distribution at 1.9m behind the propeller, left: without PSS, right: with PSS



Change of flow direction due to lift generated by stator blade, left: resistance simulation, right: self-propulsion simulation

reference computation was made for the base PSS configuration selected; the four-bladed stator was initially set at what was tentatively expected to be the optimum configuration. The effect of the PSS on the improvement of propulsive efficiency was investigated through detailed analysis of local flow quantities around the stator blades.

More as a pre-optimisation study in the second step, a systematic computation was made for the stator blade pitch angle variations and the two most promising PSS design alternatives were selected for further confirmation through tank tests.

## Energy loss reduced

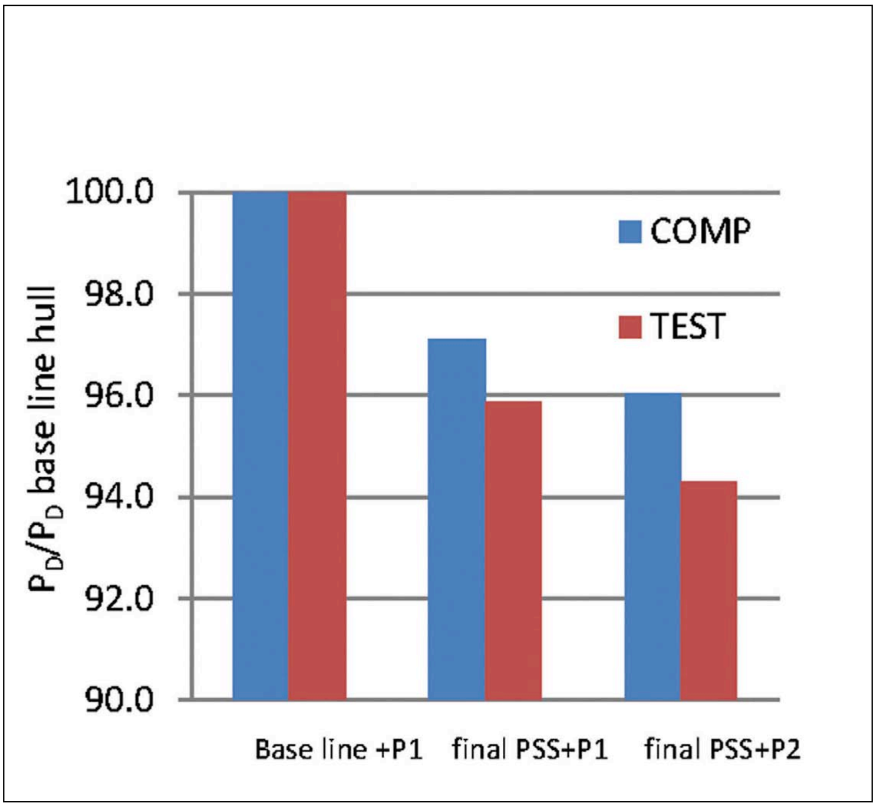
By putting the PSS in front of the propeller, more rotational flows are generated, particularly on the port side and the rotational energy loss is reduced in the propeller's slipstream. This can be also seen clearly from the comparison of the velocity distribution from self-propulsion velocity distribution behind the propeller in illustration above top. The distribution of rotation velocity components behind the propeller are plotted for the bare hull and for the base PSS configuration. It is clear that the loss of rotating energy is considerably diminished by the stator.

The illustration (below left) shows how the flow direction changes due to the lift generated by the stator. The lift is developed mainly by the mid to outer part of blade (some separation occurs due to high angle of attack locally in the mid-span), while there is no significant effect on lift by the inner part of the blade.

## Computation results confirmed

Based on the evaluation of power gain and detailed analysis of flow characteristics, four of the most promising PSS configurations are selected and tested. The table below indicates that an approximate 6% power gain can be achieved by the best PSS as compared to the bare hull. SHIPFLOW computation was able to correctly predict the relative ranking for all PSS configurations tested. CFD simulation coupled to model testing can be a cost effective approach to develop an ideal configuration of ESDs for the future. *NA*

Power reduction



# Focusing on the 'Green' target

**The on-going concern for energy resources and emissions reduction remains a major topic for maritime research and technological development. Scott Gatchell, and Jochen Marzi, of Hamburgische Schiffbau Versuchsanstalt GmbH (HSVA) look at the projects in which HSVA are involved**

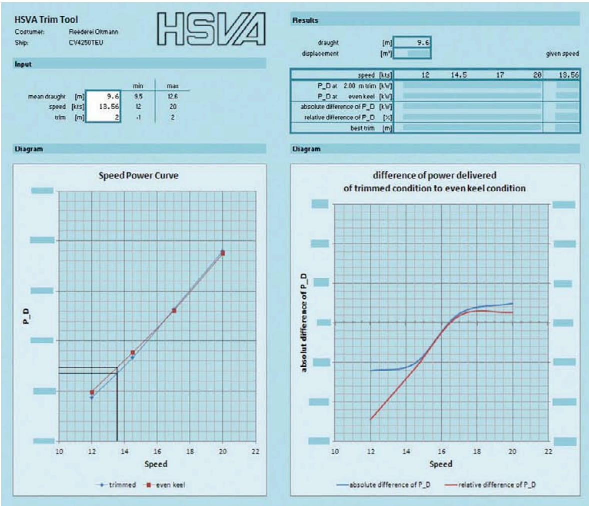
HSVA is involved in several research projects to investigate various aspects of energy use and emissions output of a ship over its entire life cycle. These developments are based on the application of the latest CFD techniques implemented in the in-house code *FreSCo+*. The maritime industry benefits from this research by improved ship performance in designs and operations.

In the following article, the latest developments are introduced through the investigations of two bulk carrier vessels- one theoretical and one actual ship. The goal is to improve energy use and, indirectly, reduce emissions.

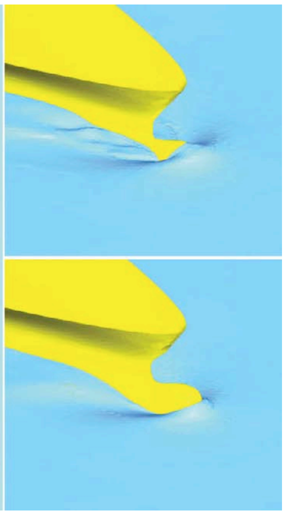
The results of these investigations are partly already in use for real-world applications from which noticeable fuel savings have been reported.

The research team in the project FORM-PRO, conducted with the support of the German Federal Ministry of Economics and Technology (BMWi), made two giant steps towards the development of new, more efficient hullforms. In the project, a new solver was developed using adjoint equations which compute the sensitivity to disturbances of a target variable or function inside the RANS code *FreSCo+* parallel to the solution of the momentum equations (Rung et. al. 2012). This has been described earlier in more detail also in (Marzi et.al. 2012). An important aspect of this development is the pliability of the adjoint solver for high Reynolds Numbers, thus making it suitable for ship flow computations as well.

As a final task in the recently accomplished project, HSVA applied the newly developed adjoint solver – now being part of *FreSCo+* - to the optimisation of a bulk carrier with active propulsion. The fully automated optimisation cycle including parametric geometry definition, grid generation and RANS prediction resulted in an asymmetric aft body.




Prediction tool



Starting with the parametric form description of a baseline design, the optimisation was set up using the delivered power (PD) as an objective function in the adjoint equation. Computations were run in "propulsion mode" using the well-established RANS-BEM coupling algorithm in FreSCo+. The form modifications followed the predicted sensitivities on the hull depicted in the figure above. The result obtained after less than 20 iterations indicated a reduction of PD for a target speed of 14knots by more than 2.5%.

To validate the computational results, model tests were performed for the – symmetric – base line design and for the optimised asymmetric aft body in HSVA's large towing tank. The experiments confirmed the superior performance on the asymmetric hull, indicating an even greater reduction of more than 4% for the design speed.

Although the asymmetric hull form is clearly not an option for retrofit of existing vessels, the concept – once again – indicates a clear way forward for new ship designs with improved propulsive efficiency. The main advantage of the design is the negligible penalty on resistance. Simulations as well as the experiment indicate that the total resistance of the bulk carrier was not affected by the asymmetric stern shape. This is hardly the case for "external" energy saving devices, such as fins or ducts, which can also be found on newly built ships to improve propulsive efficiency. The present design approach used for the bulk carrier also maintains a vertical stem contour, which limits the asymmetry to frame sections inside the hull only. This is expected to further ease the production of such vessels.

The EU funded TARGETS project – Targeted Advanced Research for Global Efficiency of Transportation Shipping (*www.targets-project.eu*) – provides substantial improvements to ship energy efficiency by adopting a holistic approach to model and optimise energy consumption with a focus on a variety of operational conditions encountered through the life-cycle of a vessel.

In contrast to the typical ship design, which is usually directed to optimise the design speed operations without considering the time and energy spent at other conditions, a life-cycle based approach uses operating profiles to represent the real life operation conditions such as speed, draft (as a function of the loading condition), fouling, water depth, weather conditions, etc. with suitable probability distributions, obtained from actual operations. These inputs are represented by a probabilistic approach. Any current or future energy reduction options may be analysed for their energy saving potential (ESP). ESPs are defined as the room for improvement, which can lead to increased energy efficiency and decreased energy consumption.

This method was applied to an existing bulk carrier. A dynamic energy model (DEM) simulated the performance of the bulk carrier *Star Aurora*. Some information for the DEM originated from onboard energy audits over a typical voyage. The remaining datasets were provided by RANSE computations over various loading, trim and speed, and surface roughness combinations. These computations formed a set of response surfaces of the ship's performance.

An extended demonstration of these developments involved a modified hullform for *Star Aurora*. The computation results for the modified hullform were likewise put into the DEM simulation to compare the ESP against that of the baseline hullform.

These research projects are already seeing real world applications and paying off. A recently completed investigation for a client of HSVA has led to a spreadsheet tool for determining the proper static loading and trim condition for lower fuel consumption. The task was to predict the required delivered power at different draughts for different trim angles, with the aim to define the optimal trim angle for a given draught at a desired speed. A series of speed and trim variations were computed in *FreSCo+* and compiled into a set of response surfaces, made available onboard in a spreadsheet tool.

As a result of the investigation a decrease of delivered power of up to 13.3% has been predicted for a good trim condition when compared to even keel, as well as power increases of up to 17.6% for poor trim selection. From this, it can be seen that trim variation can have significant influence on the power consumption of a vessel. The operator has reported from the captain a noticeable fuel savings with the help of this tool. *NA*

# CFD aims at calm water design

This article discusses some recent MARIN developments in the area of potential-flow solvers used for design optimisation. MARIN takes a look at how different CFD tools, developed in-house, can be used to improve ship designs in specific parts of the design process

Today, CFD is increasingly used in practical ship design projects. For many years potential-flow solvers were used routinely to optimise the front part of ships, for example, in order to minimise wave resistance. For the aft ship, however, where the flow is often dominated by viscous effects, viscous flow solvers have to be used.

Nowadays it is not unusual in ship design to analyse the results of a limited number of viscous flow (RANS) computations, where the propulsor is modelled in a rudimentary way in order to limit computational effort. From the results recommendations on hull form changes are derived. However, better quantified improvements can be obtained by automatic optimisation procedures based on a series of CFD computations with different hull forms, enabling the study of trends. And, next to that, introducing more sophisticated propeller representations into the viscous flow computation will lead to further knowledge on hull-propeller interaction, propeller design and CFD-based speed power predictions.

In an early stage of the hull optimisation process it is important to capture a wide range of possible hull shapes and propellers. Reducing complexity and computational time, either by ruling out physics (e.g. inviscid calculations) or omitting ship details (e.g. appendages, propellers) is tempting but, can result in sub-optimal designs.

Therefore, MARIN's in-house team developed a RANS optimisation tool, PARNASSOS Explorer (*Van der Ploeg and Raven (2010)*), to perform a quick and thorough investigation of a wide range of hull shapes, including propeller interaction. Multi-objective optimisation at full-scale Reynolds numbers can be performed in which the required power to sustain a given ship's speed is minimised and the quality of the inflow to the propeller is optimised, by minimising the variation of the angle of attack on the propeller.

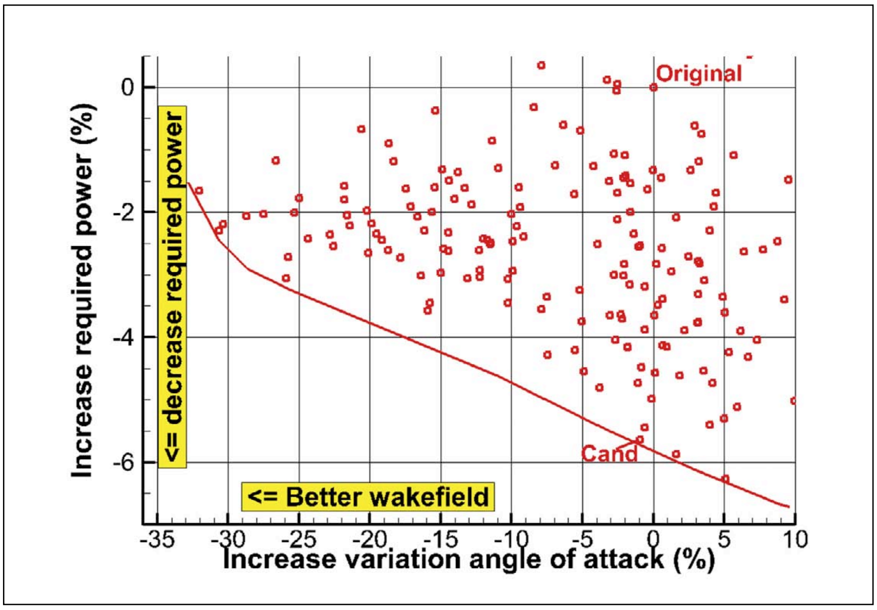



Figure 1: Pareto front obtained with full-scale RANS/FS computations

The GMS-Merge tool is used, which varies hull forms by a special interpolation between some pre-defined basis hull form variants. This allows it to benefit from the ample experience at MARIN, by adding new basis hull forms in the process. The power and performance of the propeller can be computed by including a propeller directly in the RANS computation or by coupling the RANS hull code with a boundary element method (BEM) propeller code.

The propeller geometry will not change, because of the substantial increase of optimisation parameters and computational effort this would take. However, fixing the propeller geometry would result in an optimal hull for the particular propeller chosen, instead of optimising both in combination. Therefore, a different approach is followed: the achievable performance of the propeller is obtained from the B-series of propellers. In this way, also information about the properties of an optimised propeller for the optimised hull form is obtained.

Recently, the PARNASSOS Explorer suite has been extended with the possibility to take into account the ship's wave making. By a special iterative approach the steady wave pattern can be computed efficiently (Raven, van der Ploeg and Starke, 2004). This allows us to study how modifications of the hull form near the water line influence e.g. wave resistance, propeller inflow and required power. We have demonstrated this in a systematic variation of the aft part of a single screw chemical tanker, one of the test cases used in 7th-Framework EU project STREAMLINE. Further information can be found about the STREAMLINE project in January (pg28-34) and March (pg18-22) *The Naval Architect* magazine.

The design space was set up by six distinct hull shapes varying e.g. the gondola, pram or V-type frames, transom width, buttocks slope. Using an internal network of PC's, hundreds of hull forms are evaluated in only 24 hours.

Results (Figure 1) show the first appearance of an envelope, a 'Pareto front', indicating the best that can be achieved; and a compromise between both objectives is clearly required. A candidate hull form was found which has a significant gain in required power (5.8%), without a decrease of the quality of the inflow to the propeller. The reduced waterline curvature and higher transom immersion result in a less pronounced stern wave system (Figure 2). Based on the insight thus obtained, further improvements can be made, leading to a sharper Pareto-front (more acurate data curve) and more knowledge on the most optimal hull-propeller combination.

With hull lines being (almost) final the next step in ship design is propeller design. In order to do so, often the nominal wake field (propeller inflow without propeller effect) is used as a starting point. However, CFD can provide much more information than only nominal wake fields, by looking at the hull-propeller interaction in detail.

In recent years the coupling of a RANS code with a BEM propeller code is applied more often. Also in the coming years BEM will be used for the analysis of ship propellers due to their low CPU time requirements and relatively simple gridding procedures in comparison to viscous flow solvers. However, by splitting up the analysis of the ship hull and the propeller by separate programmes, the interaction between the two still needs to be taken into account.

With respect to the wake field, this implies that the nominal wake field needs to be transformed into a total wake field of the ship with a working propeller minus the induction effect of the propeller, the so-called effective wake field. MARIN has developed an effective wake field methodology based on the coupling between their RANS codes (either PARNASSOS or ReFRESCO) and the BEM code PROCAL (*Vaz and Bosschers, 2006*).

The flow around the ship hull is analysed with the RANS solver using a body forces model to represent the influence of the propeller on the flow field. The forces that need to be applied in the RANS solver are determined from the BEM which requires an effective wake field as input. In this way the propeller flow analysis and propeller design better incorporate the hull-propeller interaction, leading to better propeller designs.

Evidently, next to the effective wake the RANS-BEM approach can also provide a better quantitative speed-power prediction for a given ship-propeller combination. Currently, an absolute power prediction directly from RANS-BEM is not always possible within 5% accuracy, compared with model test results. Reasons for this can be found in the limits of the BEM modelling, the viscous correction on the propeller torque in BEM, and omission of the full interaction of rudders with the flow. However, the RANS-BEM approach is powerful and time-efficient and can play a very important role in speed power prediction and the comparison between ship designs.

Especially in the field of EEDI-verification RANS-BEM can already play an important role in determining the speed power of sister ships. Knowing the absolute speed-power relation of the original ship, the RANS-BEM approach can provide the power offset from this design to the sister ship design, accounting, of course, for the limits of the approach at this moment. Special attention is paid to RANS-BEM applications in several MARIN projects and especially for speed-power in the CRS-SPEED-working group.

For applications where not only the viscous flow around the ship is important, but also the viscous flow around the propeller should be modelled in detail, the RANS-BEM approach cannot be applied. Some examples are: very tight clearances between ship, appendages and propulsor, dynamic effects due to the propeller rotation, and cavitation. Here RANS simulations both for the appended ship and the propeller have to be considered. The MARIN in-house unsteady RANS code ReFRESCO is developed for this purpose (*Rijpkema and Vaz, 2011*). Using techniques such as non-conformal and sliding interfaces, developed within STREAMLINE, the combination of different objects having different rigid-body motions can be simulated.

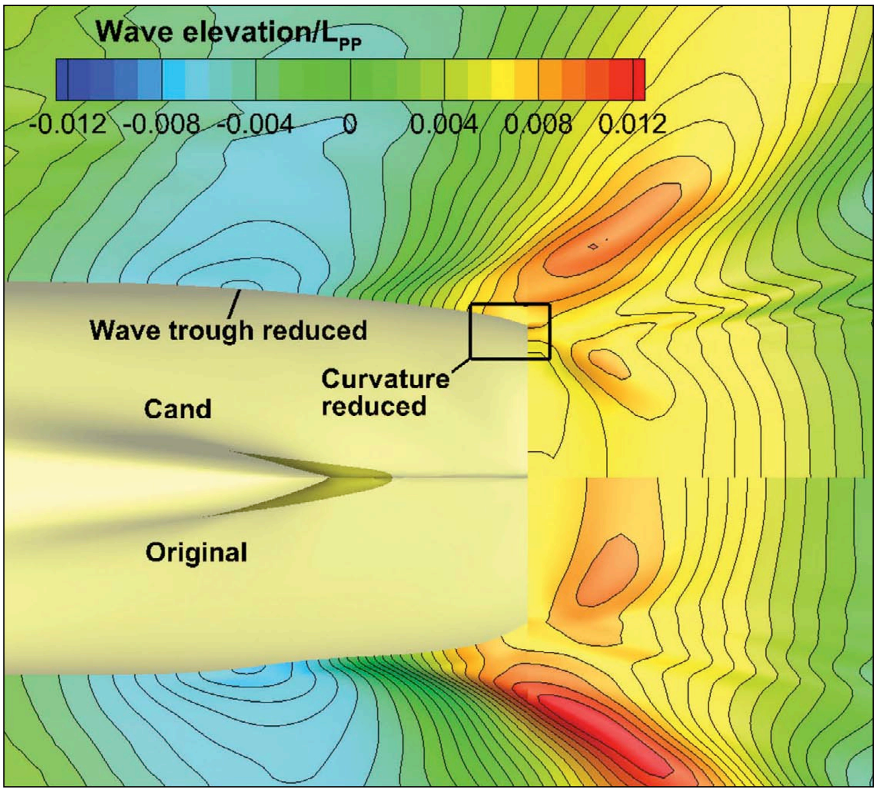



Figure 2: Comparison of the stern wave systems of the candidate and original hull lines showing the positive effects on the wave system

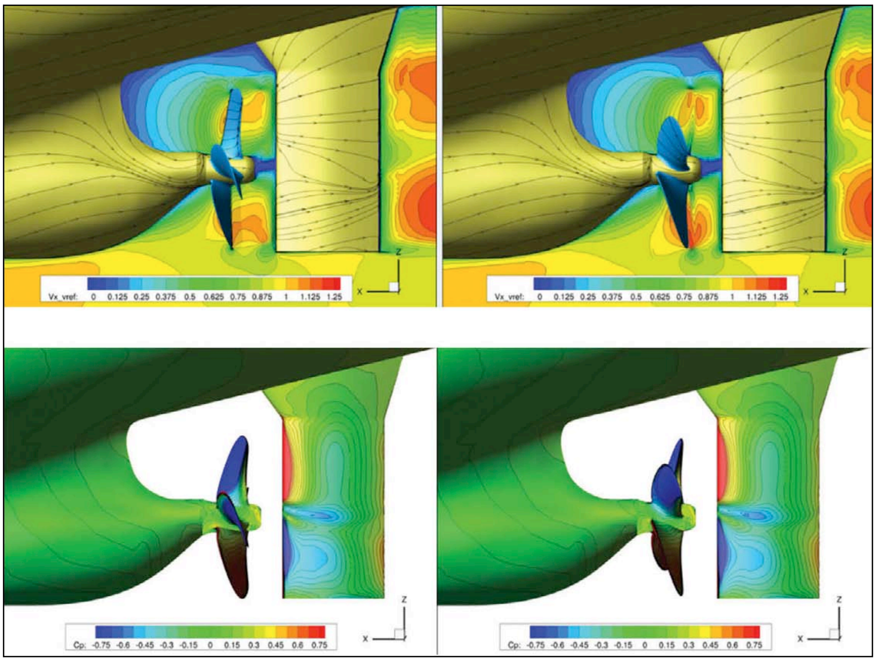



Figure 3: Limiting streamlines, axial velocity field, pressure distribution on the ship and propeller, for two different angles of the propeller rotation. (left) 0degs; (right) 36degs.

With time-averaging approximations for the propeller in full RANS calculations the computational effort, but also analysis accuracy, can be lowered. However, the most accurate approach is to simulate the real rotation of the propeller domain leading to unsteady calculations (so-called sliding interfaces approach). Figure 3 shows the results of such a calculation, illustrating the limiting streamlines, the pressure distribution on the hull, axial velocity field, for two different angles of the propeller rotation for the single screw chemical tanker.

The amount of information that one gets with these types of calculations is considerable (see also the QR code for an animation of the simulation). However, with preparation (geometry and grids) and calculation times in the order of weeks these calculations are chosen with care and often used in the final design stage and design verification.

MARIN is currently studying hull-propeller-rudder interaction and the working principles of ESD's in more detail in internal studies, the Joint-Industry-Project (JIP) ReFIT2Save, and the EU Project GRIP. In future studies details of the flow around and working principles of, other appendages like e.g. tunnel thrusters or stabiliser fins will be investigated in more detail in order to make the next steps towards a full insight in the viscous flow around appended ship and propulsors. *NA*

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# Damage stability featured in Paramarine V8

## Qinetiq GRC has launched its latest version of Paramarine V8, which amongst other features now includes the damage stability rules

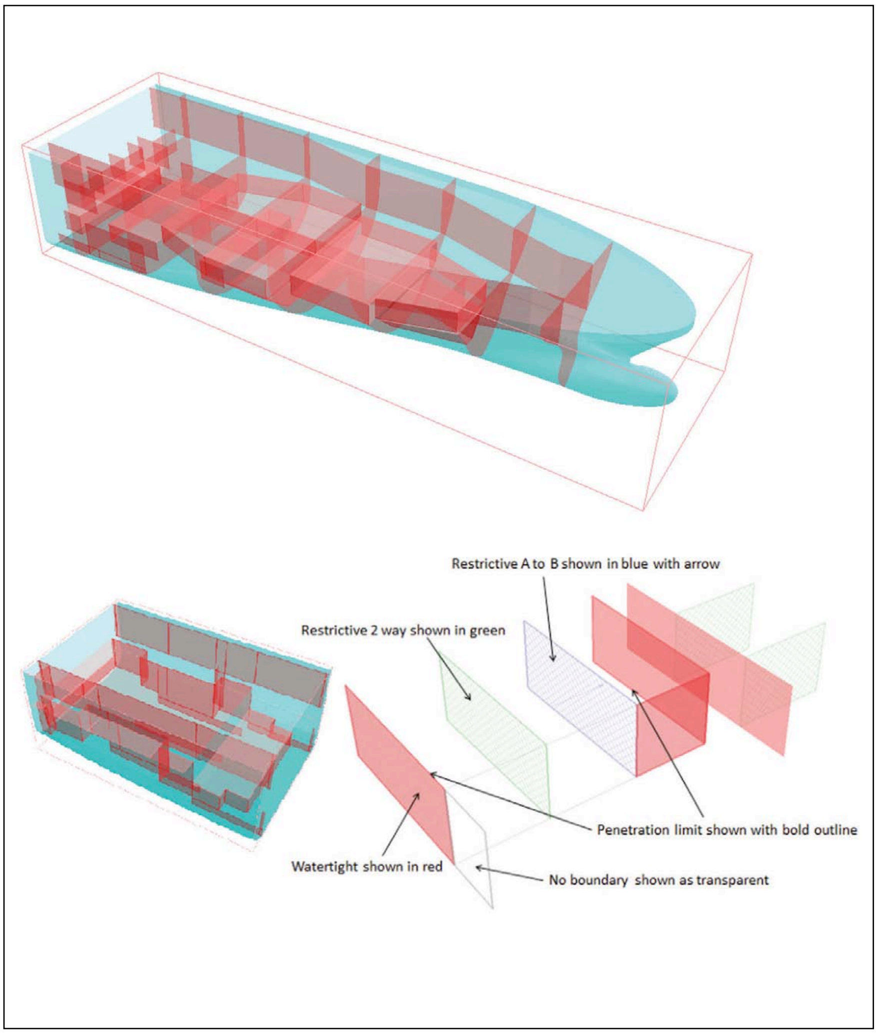
The new functionality in Paramarine V8 is intended to further meet the needs of commercial ship designers and builders, whilst expanding Qinetiq GRC's client base.

A major addition in the latest version of Paramarine is the introduction of probabilistic damage modelling and assessment, a requirement for all passenger and cargo vessels. Coupled with its innate parametric functionality and a flexible reporting system, Paramarine aims to deliver a comprehensive set of visually interactive and intuitive analysis tools allowing the user to rapidly examine the results and focus efforts for improving the design, ultimately saving both time and money, says Qinetiq.

"One of the major improvements to the software is the ability to model to the SOLAS 2009 probablistic damage stability rules. We've had lots of interest from customers about this and have teamed up with Safety at Sea who have provided support in implementing these Rules", say Vittorio Vagliani, managing director, Qinetiq GRC.

The latest version (V8) delivers SOLAS 2009 probabilistic damage assessment, enhanced and improved reporting, generating faster reports and providing a greater degree of report customisation, improved ship structure definition allowing greater detail and speed in analysis, upgraded emergency response capabilities, enabling Paramarine to carry out multipoint, sandbank or shelf grounding assessments and modelling, enhanced stability assessment for new, refitted or substantially modified ships.

Vagliani notes the challenges of implementing these rules into the software: "The Rules are interpretation based; the whole Rule set is very complex. We focused on making the software easier to use for users that will allow them to get designs passed to the standard of the Rules quickly and simply as possible."




Visual Representation of Boundary Definition for SOLAS 2009

The latest version of Paramarine also comes with enhancements to its Emergency Response functionality providing a number of assessment tools for free-floating or grounded vessels. The functionality allows the user to understand the current situation and predict the future developments of the incident as time elapses, enabling investigation of the effects of tide cycle, pumping and flooding of tanks and spaces, and the movement of solid weights.

"Over the last 24 months we have seen a very rapid growth across the world in the number organisations using the extensive functionality offered by Paramarine. We are committed to continually enhancing and improving the software's capabilities as demonstrated by this announcement and the addition of some new powerful capabilities in V8," said Vagliani. "We hope that by including the Rules into the software that we will be able to service a larger market and see growth in other markets." *NA*

# Getting in the flow

Iran's Amirkabir University of Technology has analysed the propeller hub as a non-lifting body and the blades in its vicinity as lifting bodies using the boundary element method Hassan Ghassemi, associate professor, Amin Mardan, PHD and Abdollah Ardeshir, PHD, report

The geometrical modelling of hub, blades and PBCF (Propeller Boss Cap Fin) are constructed, and then the effect of the PBCF on the propeller is determined by the Ship Propeller Design (SPD) software. The induced velocity of the propeller was calculated with and without PBCF downstream.

The PBCF is an energy-saving device that reduces and uniforms the induced velocity of a propeller in the downstream flow. Numerical results of the propeller hydrodynamic characteristics including the hub effect, induced velocities and PBCF influence are presented in this article.

Ordered for 2,000 vessels worldwide the PBCF is an energy-saving device that is attached to the propellers of a vessel and it works by breaking the hub vortex generated behind the rotating propeller (Figure 1).

Research and development studies on the PBCF started in 1986 and sales began the following year. Since then an increasing number of shipowners, mainly in Japan, have adopted the system. In 1988 Ouchi first introduced it with the aim of increasing the efficiency and reducing energy loss due to the formation of a hub vortex. Such a vortex contains vapour bubbles that when burst, cause noise, corrosion and vibration in the system.

By using fins, the vortices flowing on the hub are weakened and, therefore, the kinetic energy of the rotational current is retrieved [2]. Ouchi et al. [3-4]. Through extended numerical and experimental research on a PBCF they concluded that a PBCF has a significant effect on the energy saving of a vessel. It will not only cause it to avoid the hub vortex, but also increases the efficiency and reduces fuel consumption.

Junglewitz reported that the use of a PBCF resulted in hub vortex reduction and as a consequence a 2 - 5% increase in its efficiency [5]. Hsin et al. [6] presented a design procedure for a PBCF with the use of computational fluid dynamics (CFD).

The SPD software code has been prepared by Ghassemi and employed on the various propulsors such as propeller-rudder system (PRS) [7], high- skewed propeller [8], contra-rotating propeller [9] and surface piercing propeller [10], underwater vehicle under surface and submerged conditions [11].

In this code boundary element method (BEM) is employed to perform the hydrodynamic analysis of marine propellers of all types. In June 2011 at the Second International Symposium on Marine Propulsors in Hamburg, Germany, the UK BMT Defence Services presented a paper reporting on 'a before and after' speed test on an Aframax ship operated by a major firm. This showed energy savings of about 4% [12].

In this article, the presence of the fins in induced downstream effects of the propeller is analysed. The performance of the fins at the end of the hub is evaluated by changing two parameters: the angle of installation of the fin at the end of the hub and the phase angle between propeller and the fin. In addition, the effect of hub diameter and its conical angle which, are common parameters in hydrodynamic design of hull and propeller are studied.

## Modelling the PBCF

In the geometrical design of a PBCF the following points have to be noted [3]:

- The number of fins should be equal to the number of blades of the propeller
- The phase difference between the cross-section of the blade root and the fins varies from -20 to 30degs
- The diameter of the fins should not exceed 33% of the propeller's diameter
- The leading edge of the fins is located between the roots of two adjacent blades.

The first point is because each fin has to reduce the wake of one blade. The inflow velocity, rotational speed (rpm) of the propeller and the angle of attack of blade cross section determines the second point. In formulating Point 3, it is noted that increasing the surface area of the fins produces torque and reduces the efficiency of the propeller, therefore, a limitation on the diameter is imposed.

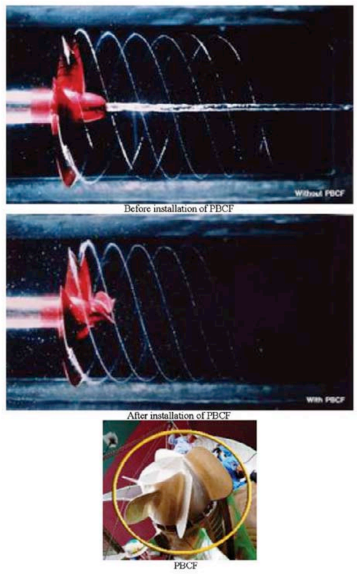



Figure 1: Hub vortex disappears after the installation of PBCF (1)

Total impact of the wake due to the fin surface is considered in Point 4. Including all these parameters into the design procedure is rather complicated. In this research, a technique was attempted to construct a model of a PBCF with the use of the above-mentioned points. Figure 2 shows a model of a PBCF with trailing vortex wake. The total number of elements is the total amount of elements on the blades, hub and fins. The total numbers of elements are equal to 8,500, i.e. 2,400 located on blades, 2,400 on fins and 3,500 on the hub. The main parameters of the propeller and the fin are listed in Tables 1 and 2.

## Performance of PBCF

Here, besides analysing the hydrodynamic effect of the fin, the change in its geometrical parameters is studied. Generally, the effect

| Parameter | Value |
|---|---|
| Number of blades | 4 |
| Diameter [m] | 1.0 |
| Pitch ratio (at 0.7R) | 1.084 |
| Expanded Area Ratio (EAR) | 0.5 |
| Skew [deg.] | 10 |
| Rake [deg.] | 6 |
| Direction of rotation | Clockwise |
| Propeller type | MAU |

Table. 1: Main dimensions of the propeller

| Parameter | Value |
|---|---|
| Number of fins | 4 |
| Diameter [m] | 0.33 |
| Angle of installation | variable |
| Chord of fin | variable |
| Direction of rotation | clockwise |

Table. 2: Main parameters of the PBCF

of the fins is to reduce the induced velocity, which in turn reduces the hub vortex. Here, the effect of the fin at the end of the hub and the effect of its position and angle on the induced velocity is examined.

## Overall analysis of the PBCF

PBCFs are not considered thrust producing devices. Their purposes are to reduce and distribute a hub vortex into a bigger core at the downstream where it is spread out. Figure 3 shows axial induced velocity contour at the downstream position, $x/R_{PBCF}$=0.5, with and without

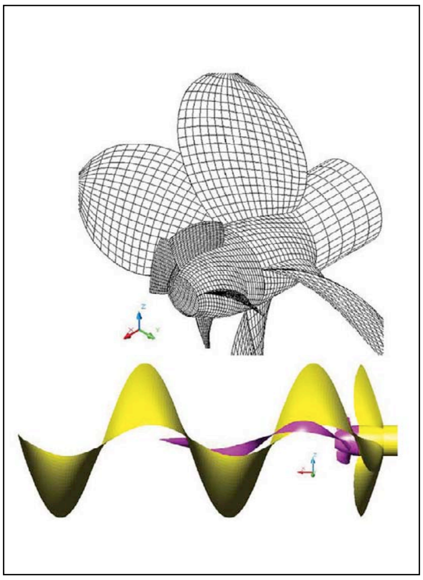


Figure 2: The PBCF model along with trailing vortex wake

fins. It may be seen that the fins caused significant reduction in maximum induced velocity and more uniform distribution of induced velocities.

The change in induced effects of the propeller in the axial direction is shown in Figure 4. Without fins, the induced effects are conveyed downstream with a certain period. This periodic feature is related to the formation of flow near the end of the hub, which is proportional to propeller's rotational speed. Installing fins at the end of the hub minimises these effects.

The most important effect of the fins is a reduction of negative or backward components of the induced effects in the axial direction. As the distance from the propeller increases the effects will be reduced.

Figure 5 shows the change in phase difference between the fin and propeller. The fin should be placed so as its leading edge lies between two blades, to give it the best performance. This has been analysed by changing the phase difference between the fin and the blades. Figure 6 shows the change in axial component of the induced velocities as the angular position of the fin is changing (phase difference of $\pi/14$ and $6\pi/14$) at the axial distance of $x/R_{PBCF}$=0.5 from the end of the propeller.

By changing the angular position of the fin, the negative component of the induced velocities has increased more.

## Effect of fin installation

The angle of installation is one of the geometrical parameters of the fin, which is

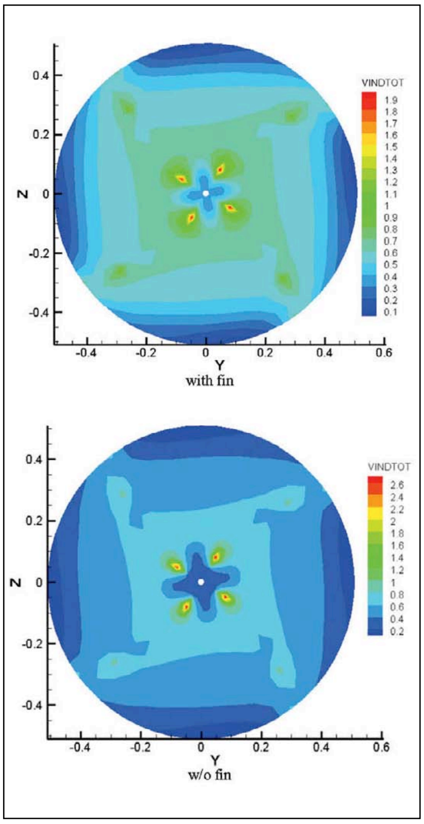



Figure 3: Axial induced velocity contour at downstream position, $x/R_{PBCF}$=0.5

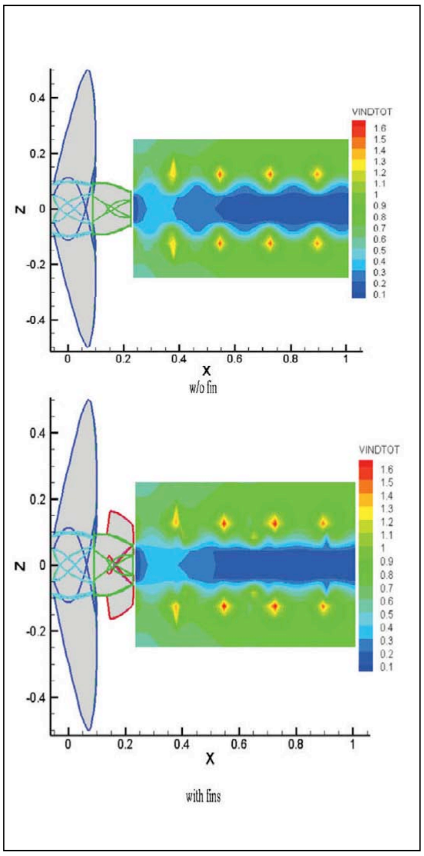



Figure 4: Axial induced velocity contour (with and without fins)

related to the pitch angle. The change in the angle of installation of the fin is plotted in Figure 7 for two pitch ratios of 1 and 2. Figure 8 shows the axial induced velocity at the two pitch ratios. In these calculations, we were seeking the effect of the angle on the axial induced velocity. The greater the angle or pitch the greater the effect of the induced velocity.

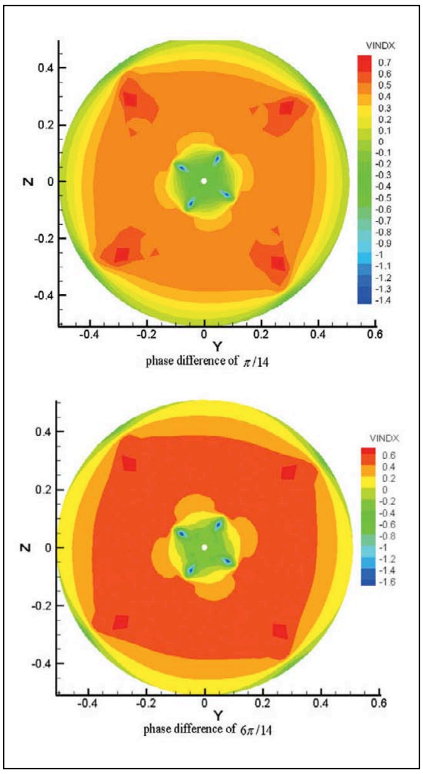



Figure 6: Change of the axial component of the induced velocity at the downstream position, x/RPBCF=0.5

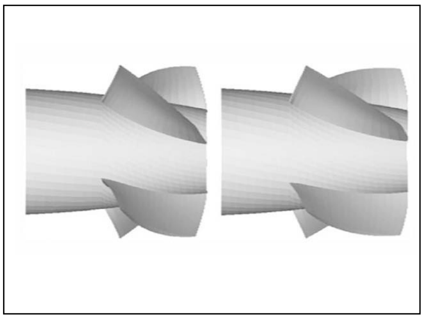


Figure 7: The change in the angle of the installation of the fin

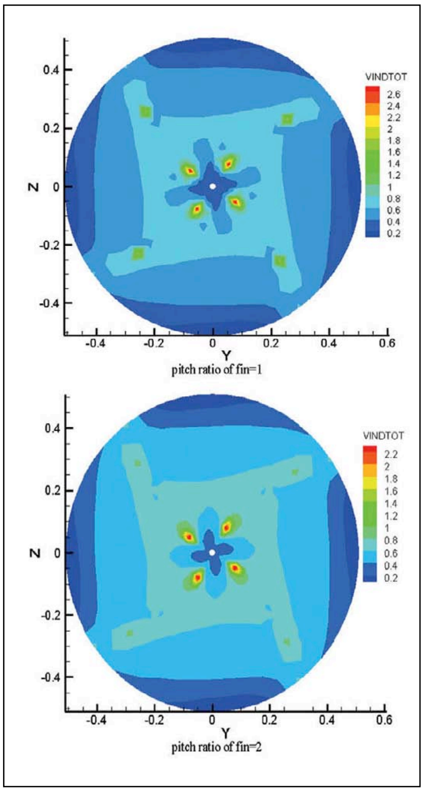



Figure 8: Axial induced velocity of the propeller at two pitch ratios of the fin

## Conclusions

From the numerical results the following conclusions can be drawn:

- At each hub ratio, increasing the conical angle of the hub has no effect on the efficiency of the propeller
- Placing the fins at the boss causes the downstream induced effects of the propeller to decrease and makes the downstream flow more uniform
- The fins reduce the negative component of the induced effects of the propeller and have only a slight effect on the components in the direction of the flow
- The angle of installation of the fin and its phase difference against the propeller are two important items to be considered in geometrical modelling of the fin, if chosen incorrectly, could significantly degrade its performance. *NA*

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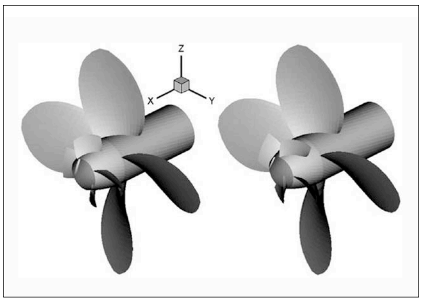
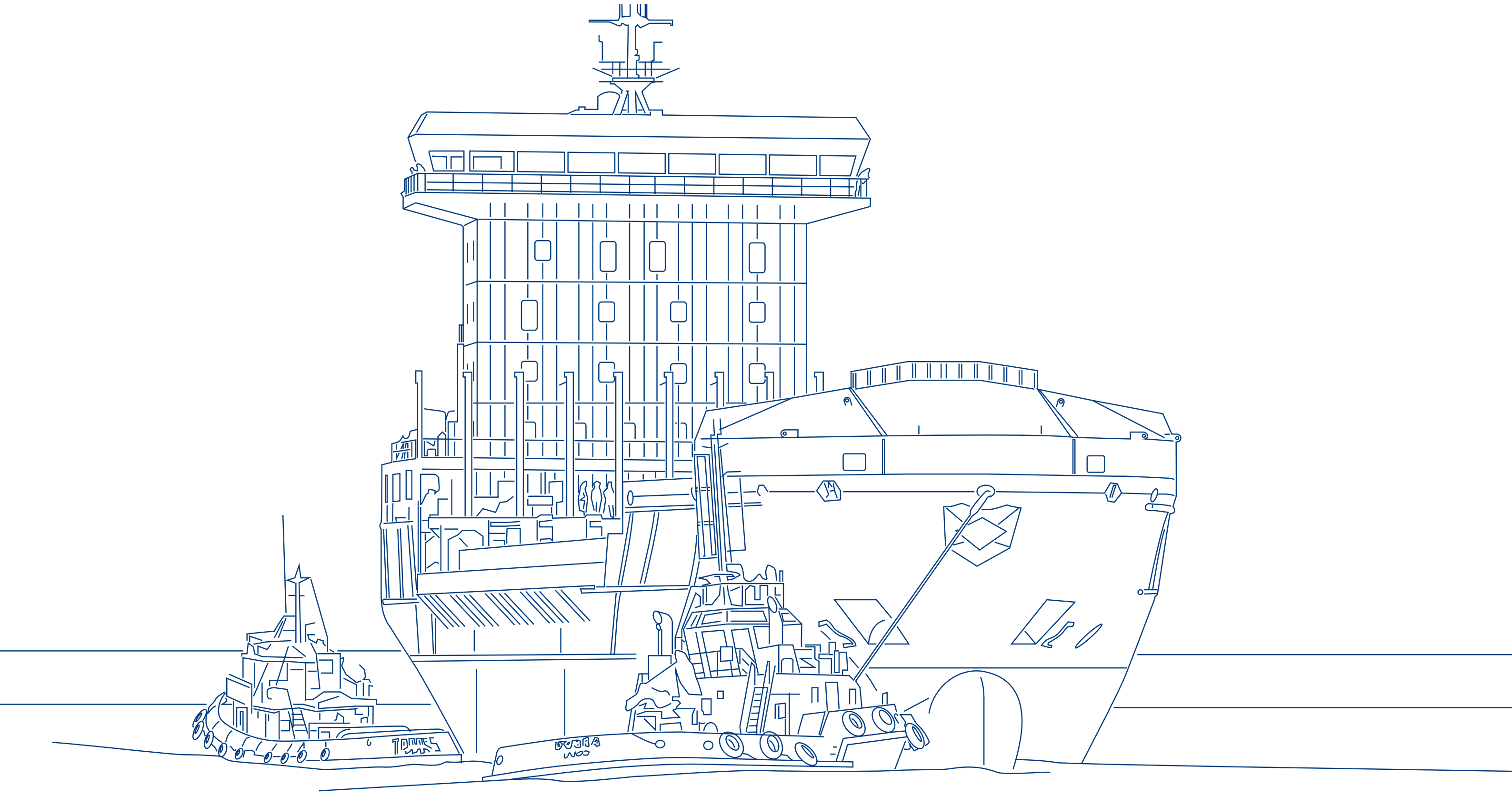
Figure 5: The change in phase difference between the fin and propeller







# Technological epiphany; between a dock and a hard place

Design-Driven Innovation has found a place between the cruise and megayacht industries to create a new breed of cruisers. This 'technological epiphany' is described by Dr Sean McCartan and Jacob Edens, both of Coventry University in the UK, in an abridged paper first delivered to the RINA Megayacht conference in Genoa in May

The cruise industry has become one of the fastest growing tourism sectors achieving more than 2100% growth since 1970. Growth in popularity has changed the luxury design meaning of cruising from its elitist beginnings into something more accessible and less exclusive.

This paper reports on a design proposal that challenges perceptions of exclusivity in the American cruise market by using Design-Driven Innovation (DDI) to create a 'technological epiphany', a new market between luxury cruising and superyacht charter; but without the numbers on a cruise ship is *Imperious* commercially viable?

The design proposal consists of a main entertainment vessel (cruise liner) acting as a mothership, which transports Small Waterplane Area Twin Hull (SWATH) floating apartments to various destinations around the Caribbean, where they are launched and later recovered, operating on the same principle as Dockwise yacht transporters. The SWATH floating apartments offer clients the freedom, luxury and privacy normally associated with megayachts.

When docked with the mothership the floating apartments are fully integrated into the interior design of the mothership. The interior design proposals for both the mothership and floating apartments have been informed by the cultural specificity of luxury in the American market.

## Floating private membership clubs

This paper and the described design project, *Imperious* megayacht, build upon the new design meaning of a cruise ship as an elitist floating private members club. A superyacht has a maximum of 12 guests, for an LOA of 45m-80m weekly charter and would range from £145,000-£550,000 (US$221,000-837,000). In contrast to this the Grill suite on the *QM2* costs in the region of £11,000 (US$16,700) for two weeks. There is clearly a market opportunity between these two price points and associated variations in luxury.

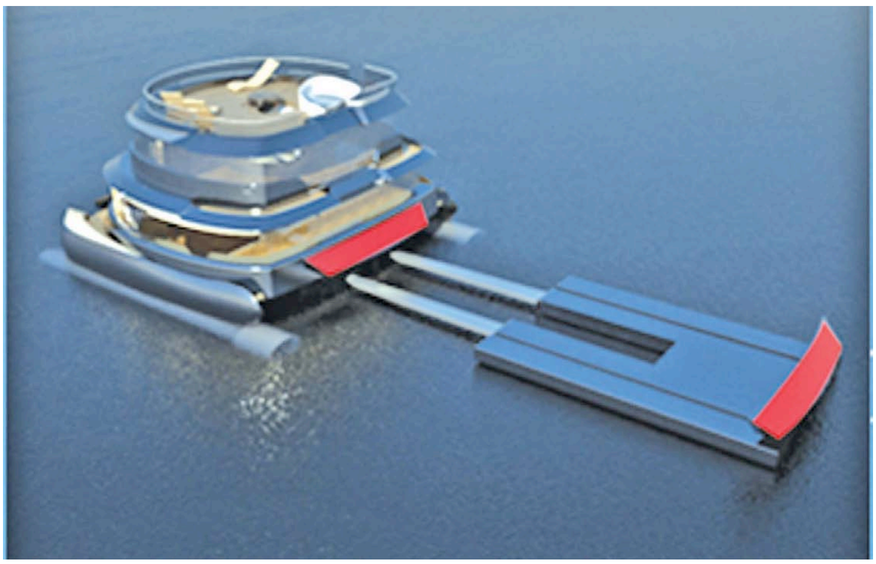
On this basis a market opportunity is proposed for an elitist cruise ship private members club, with a wider range of activities than those available on a superyacht. It would have a large theatre for exclusive events and apartments similar to superyacht guest rooms. As a large vessel, shared by a larger number of guests than a superyacht it has the potential to have significantly less $CO_2$ per person than a superyacht, addressing green envy.

Luxury has a transcendent quality that is related to a client's aspirations. Luxification refers to the continual need for designers to evolve the perception of luxury in their design process, in order to counteract devaluation through reinterpretation of their design language into smaller or higher production volume vessels. To facilitate luxification, designers must implement a DDI strategy, as clients do not buy products, but meanings. They use objects for profound emotional, psychological, and socio-cultural reasons as well as utilitarian ones. Designers should, therefore, look beyond features, functions and performance and understand the real meanings users give to things.

DDI involves a radical innovation of meaning; it has been a well-established design approach in product design with companies engaging in emotional design for the past 16 years. The interplay between design-driven and technology-push innovation is the basis of some of the most successful products such as the Apple iPod.

The process of DDI is an exploratory research project, which aims to create an entirely new market sector for a given product through changing the design meaning the user has for the product. It occurs before product development and is not the fast creative

Figure 1: SWATH Apartment with electromagnetic docking platform



brainstorming sessions that are typical of concept generation, but a design investigation similar to technological research.

In essence, it is the development of a design scenario by engaging with a range of interpreters in technology and cultural production. Knowledge is generated from immersion with the design discourse of the interpreter's groups.

The exterior design identifies the language of a superyacht, which was used to allude to the exclusivity and privacy of superyachts, as appose to the conventional form of a cruise ship, which emphasises space efficiency for a large number of passengers.

Green Envy was also a key theme in terms of technology innovation to reduce energy consumption, and the principle of using a large suite on a large shared vessel rather than the entirety of a smaller vessel, potentially reducing the energy consumption per client on the vessel. Playing on the conspicuous consumption facet of American luxury the gold membership passengers have SWATH apartments which can detach from the mothership and float off into the sunset, while being viewed by the silver membership passengers from their suites on the upper decks.

The SWATH apartments have the sense of freedom associated with a superyacht, fully serviced by a crew with comparable activities and panoramic views from all decks. Inspired by the suites of *Normandie*, they even have a baby grand piano. Separation from the mothership is achieved through the innovation of dockwise technology and an energy efficient air pumping system for deballasting.

The use of magnetic docking systems allows them to seamlessly integrate back into the mothership, where they have additional rooms in their docking station, to enhance the sense of luxury when docked.

For docking and launching the SWATH apartments electro-magnetic rod platforms have been utilised, based on the technology developed in the magnetic wharf ship docking concept. Each docking bay has an electro-magnetic rod platform as shown on the right of Figure 1.

In order to launch the SWATH apartments the ship submerges its hull by 5m and the docking bay doors then open. The magnetic rails then push the SWATH apartment to a safe distance from the ship before releasing.

Figure 2 Air vents for Trox PCM machines

The SWATH apartments have an autopilot system, but can be controlled manually by the crew from the sundeck. When docking the crew will request the ship to submerge and manoeuvre the SWATH apartment to the approximate location of the launch point. Then the autopilot system will locate the precise position using positional control and activate the magnetic rail system, which will be released. The SWATH apartments slot onto the rails and are reloaded into the docking bay. The ship deballasts its tanks and returns to normal draft.

The use of a SWATH hull on the apartment allows this operation to be carried out in moderate sea conditions. Deballasting requires low-pressure, oil-free air. For this purpose, Atlas Copco oil-free low pressure blowers have been used. The adjustable low pressures avoid the ballast tanks being over pressurised and damaged, while the oil-free operation safeguards clean air. These blowers have already been successfully installed in several submersible applications, and outperform conventional ballast pumps with regard to efficiency in deballasting time.

Research into future regulatory constraints indicates that the IMO intends to implement EEDI (Energy Efficiency Design Index), as a mandatory compliance by 2014. The EEDI is considered to be the first regulation to implement $CO_2$ standards on a global field. The regulation will require most new ships to be 10% more efficient beginning 2015, 20% more efficient by 2020 and 30% more efficient from 2025.

In addition to propulsion efficiencies this design proposal reduces HVAC $CO_2$ through the use of Phase Change Material (PCM). Air vents are incorporated above the bridge, as shown in Figure 2. Trox PCM machines are located behind these vents, and when the ship is in motion air is naturally forced into the vents.

During the day, warm outside air is sucked in by the PCM storage unit, where it is cooled and introduced into the interior. This cooling process is effective until the previously solid PCM in the storage unit has liquefied as a result of the heat it has absorbed. At night, cold air is sucked in, the PCM loses heat which is transferred to the air and solidifies, it can then be used during the day to cool the room. Depending on the design of the latent-heat storage unit, a pleasant room temperature can be ensured for up to 10 hours during the day, thereby significantly reducing conventional HVAC heating and cooling loads.

The client persona for this design project is a male multi-millionaire based in New York who has made his wealth from a media franchise. The exclusive lifestyle is something he is keen to portray and often takes part in exclusive events due to his reputation and popularity. However with such a hectic life style he often finds himself missing events and is not keen

Figure 3: Composite mood board

on yacht charter, as he is an extrovert who enjoys to network to further his media interest as well as socialising with friends. He needs a means of experiencing exclusive luxury events with people from similar socio-economic and cultural backgrounds. The floating private membership club will offer lifestyle management services with a concierge and global luxury experiences.

This is the ethos of the user experience that the design will achieve. Contemporary industrial design practices for mood boards involve collecting a series of images. Abstract images are used to enable the designer to communicate emotions, feelings and aspirations. Mood boards are a collection of visual images (e.g. photographs, material samples) gathered together to represent an emotional response to a design brief.

This technique enables designers to communicate and express themselves beyond linguistic restrictions. Designers may use this tool to communicate intangible and abstract emotions such as happiness, sadness and calm. Equally, this tool has been employed to enable users to communicate their emotional responses to products, task and their experience through abstract images.

A key aspect of the design approach presented was the combination of a series of images into a composite image to convey a depth of emotion as shown in Figure.3. The image shows an atrium staircase as the transition from a luxury interior to the beach of a small but exclusive tropical island, with palm trees in the distance. The vast expanse of shallow tropical seas fades into the sky, giving the sense of an immersive experience of a tropical environment from the top of the stairwell.

The images of a superyacht, a private jet above the Earth and a luxury sports car are superimposed on the sky as ghosted images. This signifies the various means of luxury transport that can allow the user to be immersed in this exclusive luxurious natural marine environment. The perspective view of the image suggests the view from the bow of a superyacht.

The vessel's exterior form shown in Figure 4, is a contemporary interpretation of the Art Deco and Streamline Moderne aesthetic. The overall styling theme is that of a superyacht to make a distinct break from the traditional box sided forms of traditional cruise ship design. The waist like taper of the superstructure amidship, visually accentuates the length of the vessel.

The visual form connection between each of the decks (Figure 5) was inspired by American architecture of the Art Deco period such as the Chrysler Building. The bridge wings are sculpted to connect with the flowing exterior form language. Curved stanchions on the lower decks of the superstructure connect the shear line to the superstructure, visually integrating the SWATH apartments into the exterior form. This results in an exterior with a sleek and dynamic form.

This is the accommodation for gold membership clients who would expect

Figure 4: Front 3/4 view of exterior

Figure 5: Plan view of exterior

constant service whilst on their intimate explorations of paradise. To facilitate the levels of service and privacy required accommodation for six crew has been incorporated in the design for a minimum staffing of two security guards, chef and maid, with crew rooms being sectioned from client living quarters through the use of their own stairway.

These are a duplex structure with a sun deck based on a SWATH platform to give the client the experience of freedom normally associated with a superyacht, the GA is shown in Figure 6. The lower deck has an open plan area of a lounge and bar with a spiral staircase connecting it to the master and guest suites of the upper deck.

The lounge area can be readily reconfigured to a dining area for six guests and has a baby grand piano. There is also a cinema for six guests and a massage room, as well as the entrance lobby on the lower deck, crew accommodation for six crew, the galley and stores. Two of the crew rooms have balconies for the senior staff.

On the upper deck the master and guest suites are en-suite with balconies. The sun deck has a hot tub and bar, as well as the navigational bridge. The front 3/4 view of the vessel is shown in Figure 7 where significant use of glass gives the user a panoramic view of the sea and an immersive experience.

The curvature of the structure and the glass reduces the visual mass helping to resolve an exterior form with challenging proportions. A rendered image of the lounge and bar is shown in Figure 8. The docking area on the mothership (Figure 9) enables the SWATH apartment to integrate with the structure of the mothership, where it provides extra rooms for the apartment further adding to the sense of luxury when docked.

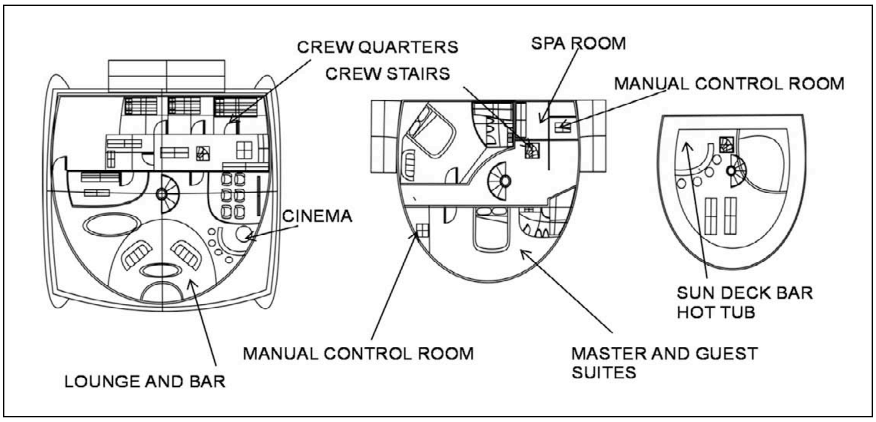


Figure 6: General Arrangement of a SWATH apartment

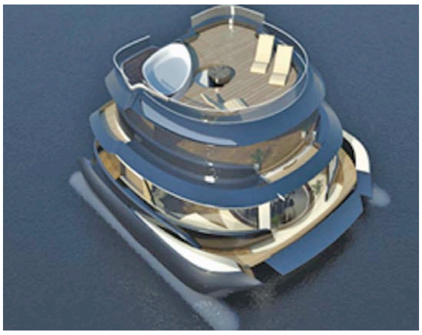


Figure 7: Front 3/4 view of a SWATH apartment


Figure 8: Interior view of a SWATH apartment dining area

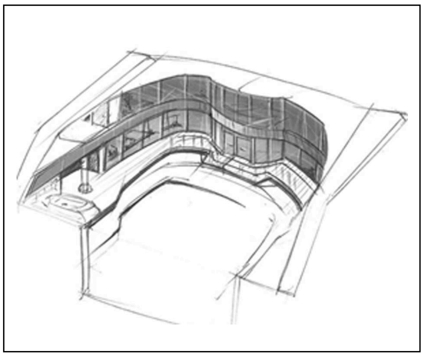


Figure 9: SWATH apartment docking port on the mothership

## General arrangement

The GA of *Imperious* is shown in Figure10a-c. The tank deck contains the ballast and diesel tanks, the bilge pumps and filtering system and the engine. Deck1 has a wet dock for storing tenders in the transom, in the fore section it has a crew galley, crew lounge and a crew cinema as well as storage areas.

Deck 2 has a main stairway at the transom connecting the upper decks, there is a corridor connecting the guest emergency exit stairways from the SWATH apartment docking stations to the lifeboats and the fore deck area. At the fore deck area the lower section of the theatre, security team quarters and crew quarters are located.

Deck 3 has an access corridor for the 8 SWATH apartment docking stations connecting them to the transom stairwell and the large restaurant area toward the bow. Fore of the restaurant area is the theatre. On the port side of the theatre is the world culture restaurant, fore of which is the sick bay area. On the starboard side of the theatre there is a bar in front of which is the casino.

At the bow there is the ballroom which has direct access to a bar aft of the port side. On Deck 4 there is a morning and evening bar aft of the transom stairwell. A central corridor connects the transom stairwell and the 10 master suites, 4 VIP master suites to the main restaurant. Either side of the restaurant there are small culture restaurants.

A central corridor connects the restaurant to the luxury shopping area in the bow. On the starboard side of this corridor is a lounge and bar area. To the port side of the corridor there is the galley, fore of which there is a museum and auction house area.

Beyond the luxury shopping area is a whiskey bar with panoramic views at the bow. Deck 5 has 10 master suites and 5 VIP master suits. There is also a VIP area with upper banquet balcony, spa and pool, wine tasting, business quarters, night bar, additional world theatre cinema, lounge and library. Deck 6 has10 master suites and 4 VIP master suites. The bridge, bridge office and Captain's cabin are located on Deck7. Where there are 2 swimming pools, 4 tennis courts, and a sun deck theatre with post performance bar.

The banquet hall shown in Figure 11, combines Art Deco themes with contemporary styles; it uses a water fountain

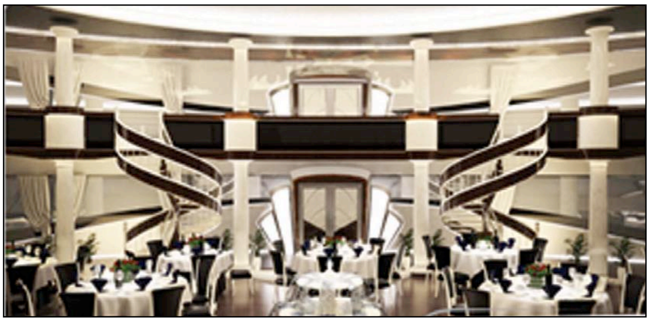


Figure 11: Banquet hall

as a focal point to the room with a balcony and winding staircases to give a sense of occasion when entering the space.

The master suite for the silver membership clients embodies art deco and neo-classical influences in a minimalistic approach, as shown in Figure 12. The circular floor feature identifies the lounge area in the centre of the room which has a coffee table, sofa and two chairs. There is a large circular light feature in the ceiling which mirrors that of the floor further defining the function of the space. The sofa is at the bottom of the bed, which has four neo-classical pillars isolating it and giving it a sense of privacy from the rest of the space. *NA*

## Conclusions

*Imperious* engages in DDI to create a new market sector between cruising and superyacht charter, based on the design meaning of an exclusive floating private members club. There are several aspects of the design engaging in emotional design, these include: the use of design language relating to American design heritage and culture, the use of the form language of a superyacht rather than a cruiseship as well as the green luxury aspect of HVAC and bilge pumping to reduce $CO_2$, helping to meet EEDI and future environmental legislation.

The SWATH apartment gives a sense intimacy, but also allows the client to dock and integrate with the interior and activities of the mothership. The range of facilities exceeds that of a charter superyacht. A full economic analysis would be required to validate the proposal given the vessel length and limited interior volume compared to a cruiseship of the same size.

A DDI assessment tool will be used to seek the professional opinion of designers in America in order to objectively determine if *Imperious* as a design proposal constitutes a technological epiphany.

## Authors

*Dr Sean McCartan*: is the Course Tutor, Boat Design at Coventry University, UK. His key research area is the TOI (transfer of Innovation) from the automotive industry to the marine industry in the areas of Design-Driven Innovation (DDI), advanced visualisation and Human Factors Integration (HFI).

*Jacob Edens* is an MDes Boat Design graduate of Coventry University who's final year major design project is *Imperious*.

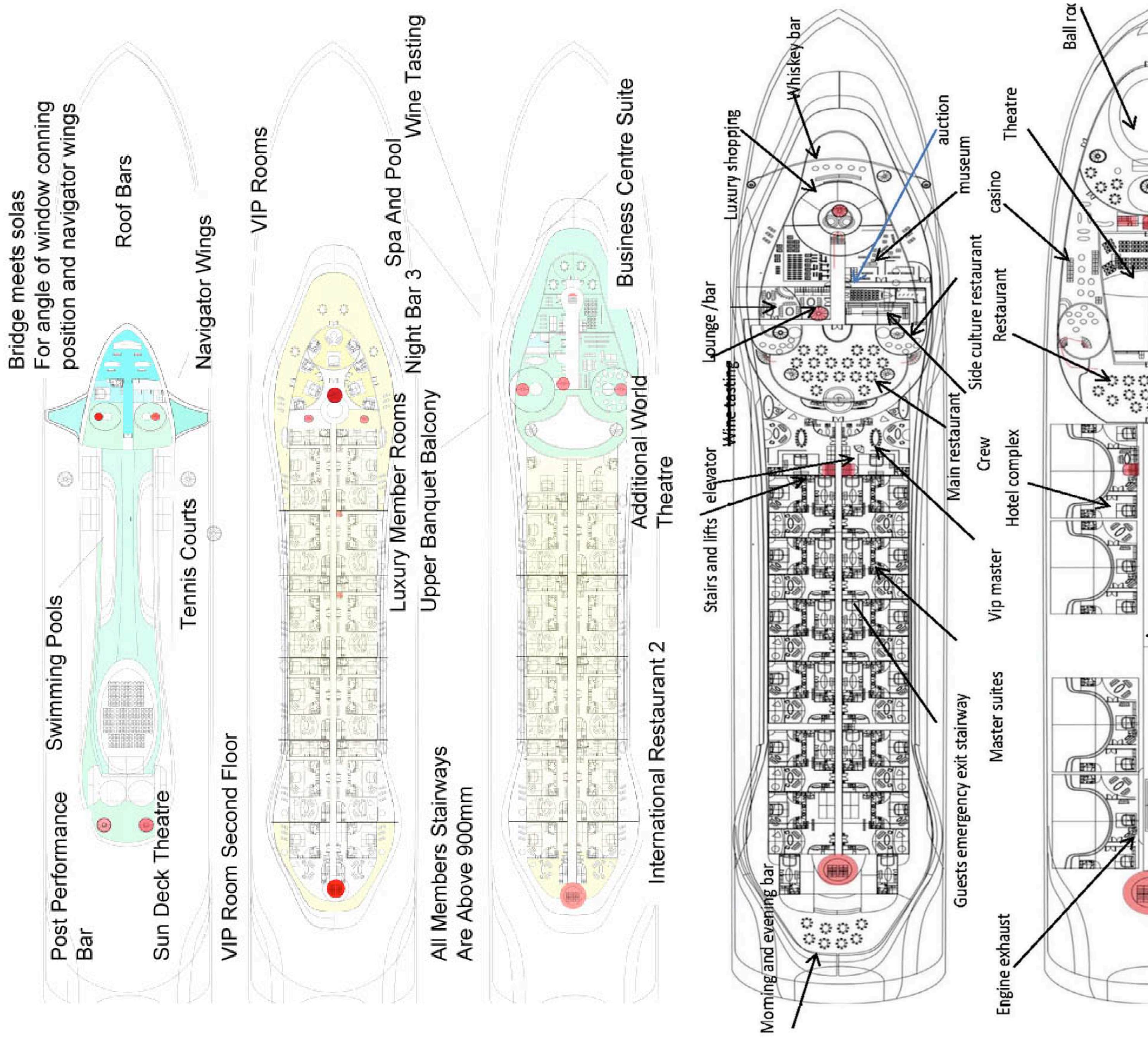
THE SUPERYACHT GROUP print digital art events

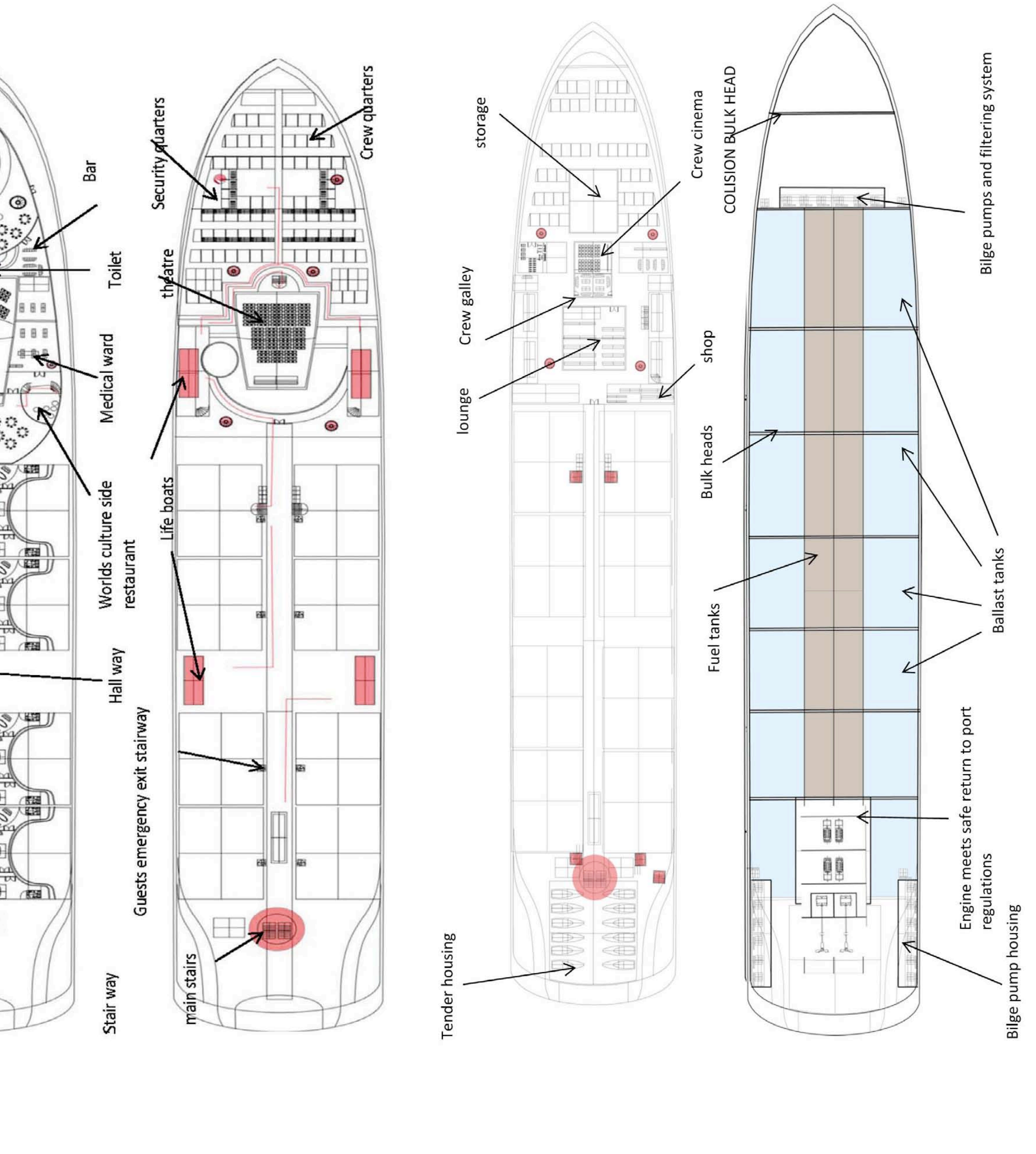
Courtesy of Superyacht Intelligence Agency

| CURRENTNAME | BUILDER | NAVAL ARCHITECT | LOAM | GROSSTONS | HULLMATERIAL | SUPERSTRUCTURE | DELIVERYDATE |
|---|---|---|---|---|---|---|---|
| VEGAYACHTS V853 | VEGAYACHTS | VEGAYACHTS / ROLLS-ROYCE MARINE | 101 | 3500 | STEEL | STEEL | 2013 |
| FEADSHIP #808 | FEADSHIP HOLLAND | DE VOOGT NAVAL ARCHITECTS | 101.5 | NULL | STEEL | ALUMINIUM | 2014 |
| SOLAR | OCEANCO | OCEANCO | 108 | NULL | NULL | NULL | 2015 |
| OCEANCO PA104 | OCEANCO | OCEANCO \| BMT NIGEL GEE | 110 | 4200 | STEEL | ALUMINIUM | 2016 |
| PROJECT 120 CZAR | NULL | NULL | 120 | 5650 | NULL | NULL | 2013 |
| PROJECT KAY | ARISTA MARINE GROUP | NULL | 122 | NULL | STEEL | ALUMINIUM | 2013 |
| VICTORY | FINCANTIERI YACHTS | FINCANTIERI YACHTS | 140 | NULL | STEEL | ALUMINIUM | 2014 |
| DREAM SYMPHONY | DREAM SHIP VICTORY LTD | DYKSTRA & PARTNERS | 141 | NULL | WOOD LAMINATE | WOOD LAMINATE | 2014 |
| 787 | NOBISKRUG | NOBISKRUG | 147 | NULL | NULL | NULL | 2015 |
| NULL | NULL | NULL | NULL | NULL | NULL | NULL | NULL |

Underlining the elitist nature of the megayacht business, there are only nine vessels of more than 100 million currently under construction

Ga plan of *Imperious*




Stair way
Guests emergency exit stairway
Hall way
Worlds culture side restaurant
Medical ward
Toilet
Bar
main stairs
Life boats
theatre
Security quarters
Crew quarters
Tender housing
lounge
Crew galley
storage
shop
Crew cinema
COLISION BULK HEAD
Bulk heads
Fuel tanks
Bilge pumps and filtering system
Ballast tanks
Engine meets safe return to port regulations
Bilge pump housing

# Tunnel thruster sizing for NavCad

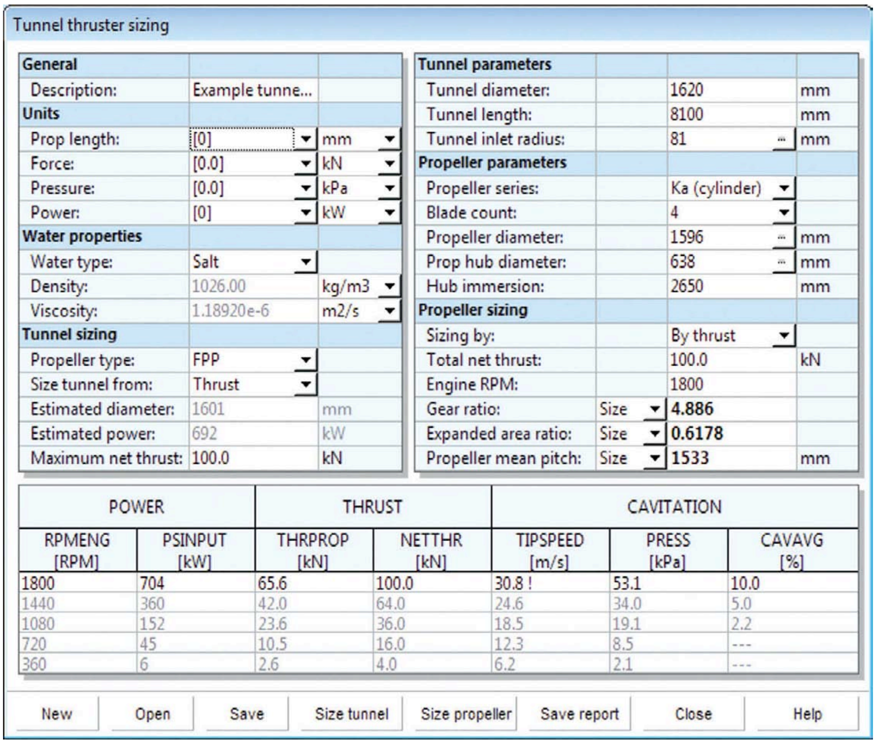
HydroComp says it has developed a reliable and accurate module for sizing and analysing the performance of bow and stern thrusters. The latest tool analyses thruster geometry for conventional tunnel thrusters. Donald MacPherson, VP technical director of HydroComp, Inc. explains further

Early in 2012, HydroComp, Inc. (with the support of Thrustmaster of Texas) embarked on the development of a new module for the HydroComp NavCad software that would provide users with a reliable, accurate, and hydrodynamically valid tool to size principal tunnel thruster characteristics.

This latest Tunnel Thruster Sizing Tool can be used to size and analyse bow and stern tunnel thruster geometry including the thruster's propeller. The current release of the tool supports conventional transverse cylindrical tunnels using a typical right-angle gear drive with a four-bladed fixed-pitch propeller (FPP) of a Kaplan shape.

The data used in this tool is independent from NavCad's active project, so no vessel needs to be defined to use the utility, and all file handling is within the utility itself. There are two principal calculation modules in the utility:

- sizing of the tunnel (diameter vs. power vs. thrust), and
- sizing of the propeller (gear ratio, blade area ratio, and pitch).




The latest HydroComp release see's enhancements in tunnel thruster performance

## Tunnel as a quasi-duct

Flow curvature into (and out of) a thruster tunnel creates a useful thrust component, much in the same way that a nozzle contributes thrust to a ducted propeller unit. Therefore, the total net thrust is the sum of the thrust of the propeller plus the added thrust from the tunnel's influence.

The prediction of a tunnel's contribution is built upon a nozzle contribution methodology developed for the HydroComp PropElements detail propeller design software. The equivalent "duct" in this model is an axial cylinder (the tunnel), where the a prediction of the tunnel thrust contribution is a function of propeller loading, tunnel inlet radius, tunnel length, propeller hub size, and the tip gap (between the propeller and tunnel wall). The performance prediction model for tunnel geometry was developed using a collection of model tests of tunnel thrusters.

## Tunnel sizing

The utility allows the initial sizing of proper tunnel diameter, input power, or maximum net thrust (given one of the three variables). For this aspect of the tool, HydroComp collected and evaluated a very large collection of published information from numerous international tunnel thruster manufacturers. The prediction of the basic tunnel characteristics is fitted from this data, whereby power and thrust are functions of the square of diameter (relating to a fundamental thrust or power loading).

This step is just for the initial sizing of the tunnel's basic characteristics, and as such, the thrust and power determined in this step are preliminary figures relating solely to the tunnel diameter. As the geometric properties of the tunnel are further defined (e.g., length, inlet radius, hub diameter), the propeller sizing step will predict real delivered thrust and power figures for the tunnel-propeller system.

## Propeller sizing

The propeller sizing feature for the tunnel thruster utility uses common propeller sizing calculation functions from NavCad. The fundamental propeller KT and KQ performance is based on HydroComp-developed prediction algorithms for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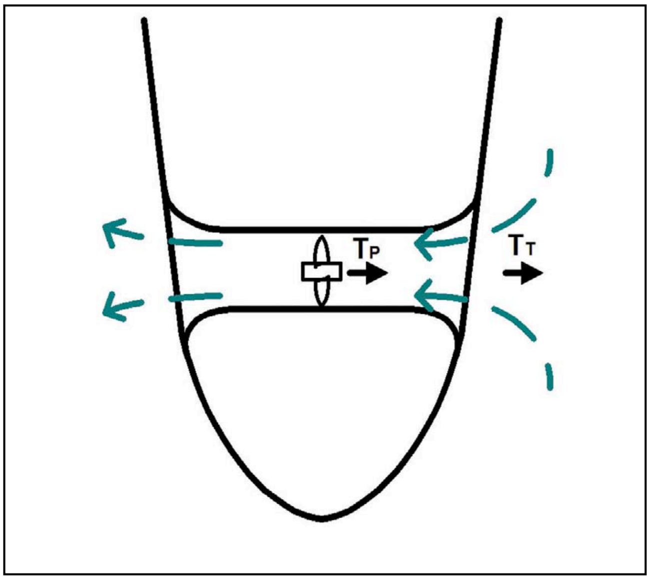


The tool can be used on bow and stern thrusters

4-bladed Kaplan style propellers in axial cylinders – with a correction to properly model fully symmetric sections. The sizing is conducted at a nominal bollard case, with proper losses applied to account for the right-angle gear efficiency. The cavitation limit for the sizing is based on a "10% back cavitation" constraint.

## Data entry and interface

The interface for the Tunnel Thruster Sizing Tool employs data entry tables for a) basic properties and tunnel sizing, b) propeller parameter sizing, and c) performance results. Processes are launched with the command buttons. A sample of the Tunnel Thruster Sizing Tool interface is shown below.

## Validation and deployment

The tunnel thruster sizing tool has been extensively tested and validated. The tool is currently deployed as part of the NavCad 2012+ platform. Planned future development includes support for controllable-pitch propellers. A separate development effort is nearly complete for the sizing and analysis of hubless rim-driven tunnel thrusters for the HydroComp PropElements detail propeller design tool. *NA*

# Design & Operation of Passenger Ships

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## Second Announcement

Continuing growth in passenger numbers mean that vessels are now operating in locations that are more environmentally sensitive and even more remote. This places new challenges not only on the design requirements of new and existing vessels, but also the operational capability and safety procedures. Recent events - such as the loss of the *Costa Concordia* and a number of machine space fires that have left vessels stranded - highlight the need to review and understand the impact of proposed legislation and the importance of continual regulatory development.

The need to balance economic and environmental efficiency with increased passengers expectations of comfort and onboard amenities, along with improved passenger and crew safety, brings new challenges for those involved in the design, construction and operation of today's passenger vessel. To further investigate this aspect of the industry, RINA invites papers from naval architects, class societies, operators, researchers, and builders on all related topics, including:

- All aspects of design – hull, general arrangement,
- Interior design, leisure facilities and hotel features
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- Current & future regulation & classification
- Environmental impact & technology innovation
- Powering & propulsion
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# Creating the mechanical alternative

## Finnish-based Steerprop has been developing its latest energy efficient mechanical azimuth propulsor

Steerprop recently finished a multi-year research and development programme to create a new mechanical azimuth propulsor available in higher power ranges than before and that combines the benefits of mechanical azimuth propulsion with unsurpassed efficiency and environmental friendliness.

The first propulsors designed under this programme were sold earlier this year with a due delivery date in early 2014. Designated the SP CRP ECO, these new propulsors are available in a range from 4MW to over 20MW.

The latest eco propulsion from Steerprop



In the past more powerful azimuth propulsion systems available to larger vessels such as cruise ships, cargo vessels or tankers were mostly limited to electrical podded solutions as component manufacturing limitations made building sufficiently large mechanical propulsors technically unfeasible, according to the company. As a response to repeated queries for a mechanical alternative, Steerprop began a research and development programme to design a large mechanical propulsor that would combine modern efficiency and reliability with high-speeds and power ranges.

Based on positive feedback from owners and operators that had for many years utilised the dual-ended Steerprop Push-Pull CRP (Contra-Rotating Propellers) azimuth propulsors in demanding operating conditions, it was decided that this new propulsor would utilise the high efficiency Push-Pull CRP configuration.

By dividing the propulsive load between two independent sets of gear wheels, shafting and propellers at opposite ends of the propulsor body, the Push-Pull CRP combines almost simplistic rugged mechanical reliability with the efficiency of the CRP and the benefits of a pulling propeller. As the two sets of gear wheels and shafting are independent from each other, the Push-Pull CRP also offers immense potential for torque – something that holds potential as a particular advantage in ice-going applications that demand high capacity for torque.

The research and development programme began with a feasibility study that looked for acceptable components that were already available on the market. As suppliers and components were located, the feasibility study created a preliminary design of a 10MW propulsor that underwent model tests in a variety of vessel configurations to verify the projected advantages of the design. The results of the model tests were promising.

"With the feasibility study we proved that we could now build CRP propulsors in the over 20MW power range in similar ice-classes".

Encouraged by the results, the R&D programme developed the preliminary design into a 20MW model enhanced with CFD-calculations to further refine the hydrodynamic qualities of the propulsor body. The design was also refined to include other new technological developments – such as pressure lubrication to eliminate losses in efficiency due to the immersion lubrication losses and a complete emissions free shaft seal that utilises pressurised air.

"In propulsion, environmental friendliness is in large part how efficiently the propulsor works – that is how little fuel it needs to propel the vessel forward," Jukola continues, "but, with the CRP ECO we looked beyond that. We made sure that the new shaft seal system is completely oil leak free and that the propulsor produces as little noise and vibrations as possible."

This design was then put to the test in comparative model tests with other propulsion solutions for a large cruise ship application that required a high efficiency propulsion system with minimal noise and vibration. In these model tests, the Steerprop CRP ECO propulsor's test results showed that it achieved superior efficiency in comparison to all other tested configurations.

But, while the CRP ECO had been tested in open water applications, the potential held by the high torque for Arctic and ice-going applications was still untested. This potential was put to the test when Steerprop. together with Aker Arctic Technology began conducting ice basin tests in a number of different vessels such as Arctic LNG-carriers operating on the Northern Sea Route, icebreakers and dedicated ice management vessels for the Northern Offshore Felds.

The results of the ice basin tests confirmed the potential for high torque to be a real advantage in icy conditions. As the propellers are located on opposite sides of the propulsor body some meters apart the propellers cannot be blocked by large blocks of ice.

The tests also revealed a surprising advantage with the CRP propeller's slipstream;the different nature of this slipstream was noticed to be particularly effective in ice-management.

The research and development programme was completed in late 2012 and the first CRP ECO propulsors were sold as main propulsion soon after for a dual-fuel ro-pax vessel to be built by Fincantieri in Italy for STQ of Canada. This vessel is due to operate year round in the Canadian waterways and is built with ice-reinforcement according to the FSICR 1A ice-class.

"We think that it is fitting that the first of the CRP ECO propulsors were sold to an ice-going passenger vessel," says Jukola.

In the months after the first contract was signed, the CRP ECO has also been contracted to a few other vessels – ranging from large naval supply vessels to technology demonstration vessels. *NA*

# New inland tanker designs from Russia

**Over the last year 26 river-sea going tankers were built for Russian companies. Igor Ilnitsky, deputy director general/chief designer, Marine Engineering Bureau (MEB), describes the design evolution of Russian inland tankers**

In spite of the 2008-2009 economic crisis MEB has seen a growth in the building of new river-sea going tankers in Russia. In the last year and a half (2012-2013) there have been 19 vessels in the RST27 project, five vessels in the RST25 project and two vessels in the RST22M projects constructed. At the present time, however, the domestic river-sea going tanker fleet is aging and leading shipowners are starting to make a move to modernise their fleets.

All the vessels mentioned above are MEB projects belonging to one of the most popular types of river-sea going vessels (RSV) in Russia "Volgo-Don Max" class, which is defined by the maximum dimensions of the Volgo-Don Canal locks and has a maximum load capacity of up to 5,000tonnes and a river draught of 3.60m; however, the load capacity for the new designs is 7,000tonnes for the maximmum draught. Such vessels satisfy the dimensions of the Volgo-Don Canal so they can be used for sailing through practically all the united high-depth system of inland waterways within the former Soviet Union.

It is necessary to build about 180-190 vessels of the new Volgo-Don Max class generation during the next five years in order

River-sea going tanker of the RST25 project built for the Moscow River Steamship Company in 2012

River-sea going tanker of the RST27 project built for VF Tanker (VBTH Holding) in 2012

TECHNICAL PARTICULARS

***RST27 project tankers***

Length overall: ........................................ 140.85m
Length between perpendiculars: ....... 137.10m
Breadth: ........................................ 16.70m
Depth: ........................................ 6.00m
Draught at SWL: .......... 4.20m (normal Caspian and Azov condition)
Draught in river: ........................................ 3.60m
Deadweight at draught 4.20 m at sea: ........................................ 7,022dwt
Deadweight at draught 3.60 m in river: ........................................ 5,420dwt
Endurance, days (sea / river): ................. 20 / 12
Tanks capacity (cargo / cargo with slop tanks): ................................ 8,100m³ / 8,274m³
Number of cargo tanks: ........................................ 6
Number of slop tanks: ........................................ 2
RS class: ............ KM✪Ice1 R2 AUT1-ICS OMBO VCS ECO-S Oil tanker (ESP)
Cargo pumps output: ...................... 6 × 200m³/h
ME power and type: .................. 2 x 1200kW 6L20 ("Wartsila")
Fuel type: ............ heavy fuel oil with viscosity of IFO380 (it is possible to use natural gas as fuel)
Rudder-propeller gear: ........ Rudder Propellers Shottel SRP1012FP
Bow thruster: .............230kW Schottel STT0170FP
Auxiliary diesel-generators: ................. 3x292kW
Emergency-harbour diesel-generator: . 136kW
Auxiliary steam boiler: ............................ 2 × 2.5t/h
Crew / berth: ................................ 12 / 14 + pilot
Number of manifolds / And sorts of cargo: ...........2 manifolds / 2 sorts
Cargo heating: ........................................ Coils
Tank wash system and cleaning of washing liquid: ........ Slop tank pump 80m³/h
Speed (at draft 4,20m and 100% MCR): ................................ 10.6knots

to replace the well known "Volgoneft" and "Volgodon" soviet series.

A distinguishing point of the latest designs of inland tankers is that the old RSV class built before the 21st century have hulls with a block coefficient of $C_b$ = 0.84…0.85. The hulls of the latest generation MEB RSV (005RST01, 006RSD02, 006RSD05, 007RSD07, RSD19, RSD49, RST22, RST22M, RST25 projects) are characterised by "thick" forms ($C_b$ = 0,88- 0,90). These features allow a river deadweight 4,700-5,000tonnes for a draught 3.60m even with the simultaneous increase of hull shell thickness and an increase of the total hull steel weight.

Earlier building of such "thick" vessels was considered absurd and was refused as it conflicted with naval architectural theory, and especially with model trial results that were oriented towards the main dimensions ratio for marine vessels. But, the successful operation of more than 60 river-sea going vessels from 2001 has fully confirmed the validity of the accepted principal design decisions.

We see a regular question appear: "Why is the restriction for RSV block coefficient increasing?" For these investigations, theoretical hull forms for a vessel with $C_b$ = 0.93 were designed. The fore end of bulb-type and transom aft end with semi-tunnels and skeg were used. Two full-turn fixed pitch rudder propellers in nozzles were used as combined propulsion / manoeuvring gauges were set.

A 3D model of the vessel's hull with outside parts was prepared for numerical investigation of the effective horsepower characteristics. For calculations validating the model, a towing test in a deep-water tank was carried out; with the model's scale of 1:16.

Two full-circle rudder propellers SRP1012 (Schottel) with fixed pitch propellers (FPP) nozzles were modelled as a combined movement and manoeuvre facility. The SRP1012 rudder propeller is a 4-blade FPP of 1.9m diameter. The geometrical elements of the FPP blades are defined by the manufacturer according to towing resistance of the hull and hull-propulsion interaction coefficients.

Towing tank test modelling was carried out by using the Reynolds equation and using the finite-volume method within a calculated area where a 3D vessel's hull model is placed.


The block coefficient of the RST 27 has been increased to 0.93

Calculations were made in the natural scale in order to avoid scale effects and to avoid model-nature re-calculations procedures. Towing power results for RSV with thick hull forms gave good CFD prediction results, which also ensured that there were no significant separation effects on the hull.

In accordance with tow tank model tests a fully loaded thick hulled vessel has an effective horsepower $P_E$ that is only 4% greater than standard vessels with $C_B$ = 0.90. At ballast conditions the $P_E$ value for a thick hulled tanker is bigger than for a standard vessel; at a speed of 10.5knots the difference is ~80kWt (about 13%). The effect of the block coefficient alternation (in the region of 0.88 - 0.93) is insignificant when using it typically for an RSV operational speed of 10knots.

The lead RST27 project vessel with the record block coefficient of 0.93 showed a speed of 11.7knots during trials at the running line with main engine capacity of 2100kWt (87.5% MCR) and fore/aft draughts of 3.2/3.3m (general arrangement of RST27 project see page 88 and picture above and on page 86).

The main advantage of the new project tanker it has an increased river function compared with other MEB projects. The river deadweight of the RST27 project vessels has been increased to 732tonnes compared to Armadas type (RST22 project with $C_b$ = 0.90), while:

- increased hull's strength (vessel is of R2 sea sailing region)
- practically keeping the same fuel consumption
- keeping increased capacity of cargo tanks.

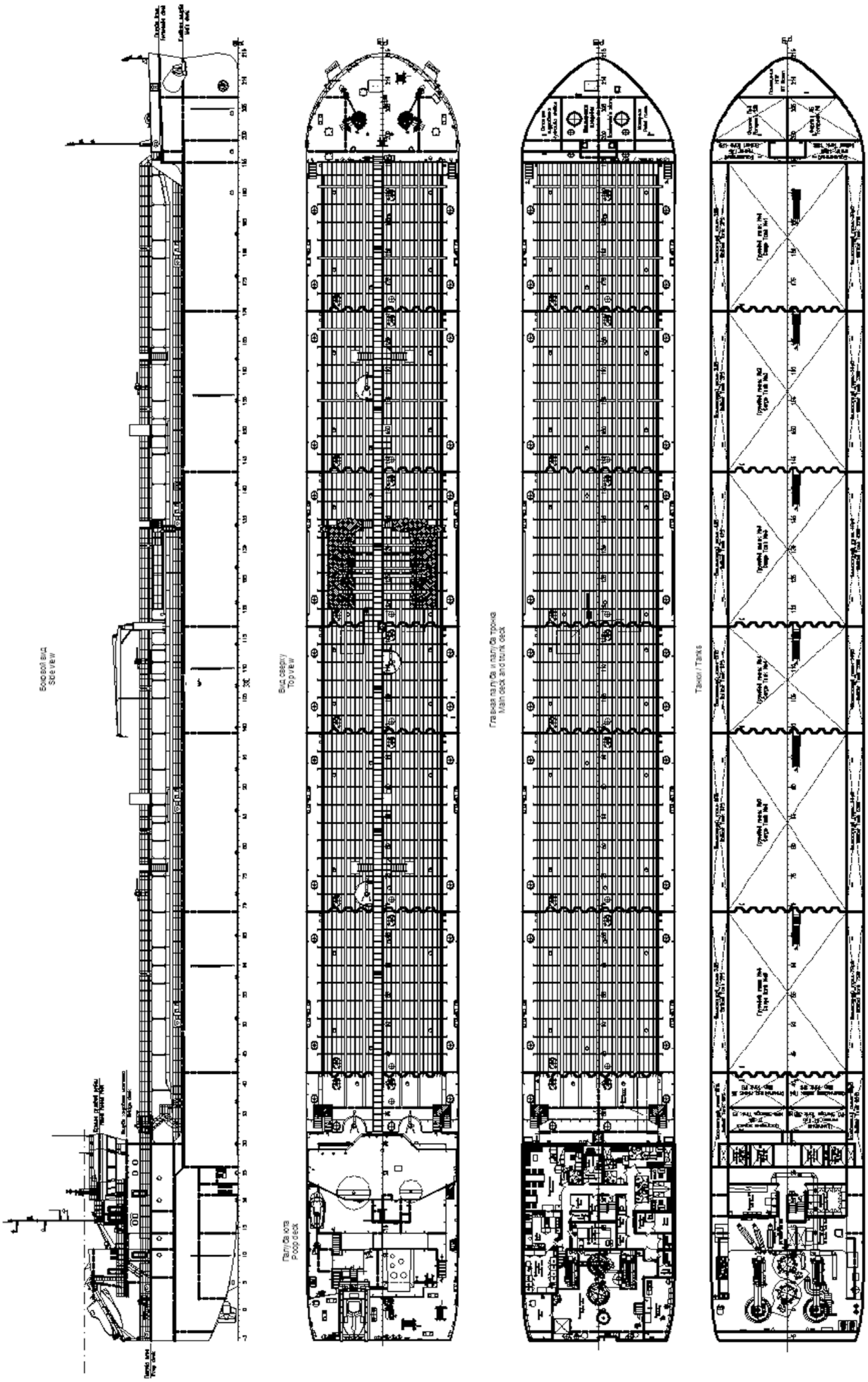
As other river-sea going tankers the RST27 project vessels use full-circle rudder propellers for single movements and manoeuvre facilities. They have an increased trunk and use submersible cargo pumps. They have no longitudinal bulkhead in the centreline (CL) and no framing in the cargo tanks.

Special requirements of the Russian and world petroleum companies, additional to the ecological RS limitations of 'ECO-S' ('Clean Design') class have also been taken into consideration during the design process. The RST27 project vessels are assigned for transportation of crude oil and oil products, without flash point restrictions. The cargo system provides simultaneously transportation of two cargoes.

Due to the vessel's unique characteristics this has caused a high interest from Russian shipowners. 32 tankers with a very high block coefficient were ordered from three shipyards (Krasnoe Sormovo in Nizhniy Novgorod, Oka shipyard in Navashino, Russia and Kherson shipyard in Ukraine) in March of 2011.

Created by MEB the RST27 project is the most innovative project of RSV, which shows the possibility of successful operation of the RSV with a block coefficient is of 0,93. This conclusion has also been confirmed by Russian shipowners of the vessels. The series of 32 RSV of RST27 project is the largest order to be realised since the breakup of the Soviet Union. *NA*

GA plan of the RST 27



The Royal Institution of Naval Architects

Design & Operation of

# Wind Farm Support Vessels

29-30 January 2014, London, UK

## Call for Papers

Offshore wind turbines are becoming an important resource of renewable energy, and large scale investment is creating extensive wind farms off the coast of many coastal European Countries. This has led to the need for specialised vessels that install and service the turbines.

The importance of transferring equipment and manpower safely and efficiently has led to a number of advancements in the sector. In particular, higher operating speeds have come to be the norm. However, this specialisation has led to the debate on the application of existing IMO instruments on their operation, and whether more specific regulation may be necessary. This is extremely important when applied to the operational environment of the crew.

To further investigate these specialised vessels RINA invites papers from naval architects, class societies, operators, researchers, and builders on all related topics, including:

- All aspects of design - hull, general arrangement, interior, etc. including innovative features
- Navigation, communication & controls - safety, efficiency, reliability
- Classification & statutory requirements - impact of new rules & regulations
- Sea keeping & manoeuvring - thrusters, dynamic positioning, trials, evaluation
- Crew safety & comfort – fatigue, health & safety, environment, operation
- Powering & propulsion - all-electric and hybrid-electric propulsion, system layout, fuel saving
- Construction, machinery & equipment - materials, techniques, quality control, products, power plant

www.rina.org.uk/windfarm-vessels.html

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# RS offers more

**The Russian Maritime Register of Shipping (RS) has been tending to the needs of the Russian fleet as it develops for further Arctic exploration and is cooperating with the Italians on Arctic navigational development**

RS has recently announced that that it will be cooperating with Italian-based RINA to exchange expertise. It will see the Russian-based classification society advise RINA on how it can help clients to meet the needs for Arctic navigation and offshore operations and in areas of ice class and winterisation.

Mikhail Ayvazov, CEO, RS, says: "RS is pleased to pursue the development of bilateral cooperation with RINA on issues that give us very good opportunities for common advancement ahead. Both RS and RINA are rather comparable in size and have complementary expertise in areas at hand. This approach, based on the principles of fair and equitable cooperation, opens very good perspectives for our companies to raise the level of our expertise in new and promising areas, where there is a demand from our clients for reliable services and where RS and RINA are committed to expand their presence."

The recent key objectives for RS have also been to take an active part in the implementation of the government fleet development programmes, to increase technical and scientific potential (R&D) especially with regards to the needs of the Russian shipbuilding industry, development and implementation of the technical standards and international rules aimed at safety enhancement for all of the maritime industry projects.

The class society has also been working closely with the developments of new designs for nuclear icebreakers, such as the LK-60 which, will be launched in 2017 and will be the largest most powerful nuclear powered icebreaker constructed. The development of the Arctic oil and gas fields and transportation along the Northern Sea Route has also stimulated the development of the Arctic fleet. *Velikiy Novgorod* an LNG carrier which was launched in January 2013 will be able to operate at temperatures of -30.

RS has also stated that it is to introduce new requirements in its Rules, concerning ships operating in Arctic seas. The requirements will refer to damage trim and stability calculations to be made for the case of ship damage. The enforcement of the new requirements is planned for 2014.

"The development of Arctic deposits will require a large number of icebreakers and ice class ships to be built. Therefore, the shipbuilding of today will need technical standards to enable a reduction of construction costs for these ships to be achieved without harm to their safety"

"The development of Arctic deposits will require a large number of icebreakers and ice class ships to be built. Therefore, the shipbuilding of today will need technical standards to enable a reduction of construction costs for these ships to be achieved without a detrimental effect on their safety. The new RS requirements focus on the current needs of the industry and will make the ice ship design and construction process highly efficient", Ayvazov says.

The RS requirements prescribed for icebreakers above 75m in length are to withstand damage to two adjacent compartments. Based on supervision of up-to-date icebreakers and ships of arctic ice categories designed for icebreaking operations, but not having 'icebreaker' assigned as their main purpose (supply vessels, for instance), the above requirements may be considered to be superfluous, notes the class society. In view of this circumstance and proceeding from international practice, RS has prepared new requirements for icebreakers and ice class ships that will have ice category marks Icebreaker6 and Icebreaker7 in their class notations.

A new RS requirement prescribes compliance with damage stability criteria for icebreakers with damage to a single compartment irrespective of their length. For ice class ships of Icebreaker6 and Icebreaker7 categories engaged in icebreaking operations and complying with the requirements of RS Rules for icebreakers, but not having 'icebreaker' assigned as their main purpose, the vessel is permitted to withstand minor ice damage generally involving double bottom tanks only and not reaching deep into the compartment.

New provisions of the RS Rules permit, upon customer's request, additional marks [1] and [2] accordingly to be introduced in the ship's class notation provided the requirements for damage trim and stability are met with one or two compartments damaged. The new requirements are harmonised with international safety standards for ships operating in polar waters (considering the provisions of IMO Res. A.1024(26) in particular). *NA*

International Conference on Ship and Offshore Technology

# Technical Innovation in Shipbuilding

12-13 December 2013, Kharagpur, INDIA

## The Royal Institution of Naval Architects

in Association with

Department of Ocean Engineering &
Naval Architecture
IIT Kharagpur

## Second Announcement

The global maritime industry faces many challenges as it seeks to recover from the financial crisis which has affected all sectors of the industry, whilst at the same time, responding to the continuing demands of operators, regulators and society for greater efficiency, safety and the protection of the environment. This response will require innovative thinking from all sectors of the maritime industry, and particularly those involved in ship design and construction.

The third International Conference on Ship & Offshore Technology - India 2013 will take "Technological Innovation in Shipbuilding" as its theme, and will bring together members of the international maritime industry to present and discuss the latest developments in the ship design and construction process which will provide the improvements in productivity and cost-competitiveness necessary to respond to the demand for lower cost of ownership and greater environmental sensitivity. Papers are invited on the following topics:

- Design and construction of all ship types
- Fabrication & welding technology
- Corrosion and coating technology
- Project management
- Material developments; alloys, composites, etc.
- Quality assurance
- Regulation
- System integration

www.rina.org.uk/ICSOT_India

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# RINA - Lloyd's Register
# **Maritime Safety Award**

The Institution believes that the safety of both the seafarer and the maritime environment begins with good design, followed by sound construction and efficient operation. Whilst naval architects and other engineers' involved in the design, construction and operation of maritime vessels and structures do not have a patent on such issues, nonetheless their work can make a significant contribution.

The Institution also believes that it has a role to play in recognising achievement of engineers' in improving safety at sea and the protection of the maritime environment. Such recognition serves to raise awareness and promote further improvements.

The Maritime Safety Award is presented by the Institution, in association with Lloyd's Register, to an individual, company or organisation which has made a significant technological contribution to improving maritime safety or the protection of the maritime environment. Such contribution can have been made either by a specific activity or over a period of time. Nominations may be made by any member of the global maritime community, and are judged by a panel of members of the Institution and Lloyd's Register. The Award will be announced at the Institution's Annual Dinner.

Nominations are now invited for the 2013 Maritime Safety Award. Individuals may not nominate themselves, although employees may nominate their company or organisation.

Lloyd's Register

Nominations may be up to 750 words and should describe the technological contribution which the individual, company or organisation has made in the field of design, construction and operation of maritime vessels and structures,

Nominations may be forwarded online at *www.rina.org.uk/MaritimeSafetyAward*

or by email to *MaritimeSafetyAward@rina.org.uk*

Nominations should arrive at RINA Headquarters by 31 Dec 2013

Queries about the Award should be forwarded to the Chief Executive at *hq@rina.org.uk*

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The Royal Institution of Naval Architects

# Human Factors

## 26-27 February 2014, London, UK

## First Notice & Call for Papers

**Supported by**

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.

This conference aims to bring together international specialists and professionals including designers, ship operators, seafarers, equipment manufacturers and regulators to highlight how an improved understanding of human factors can reduce costs and improve safety. RINA invites papers on all related topics, including:

- Design for occupational health and safety
- Integration of human factors into the design process
- Feedback from the users into the design loop
- Examples of practical applications of human factors engineering
- Habitability
- Design of navigation & control systems
- Design for performance
- Maritime operating organisations and teamwork
- Safety, performance and management
- Survivability, escape and evacuation systems

www.rina.org.uk/humanfactors2014.html

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# RINA publications

## Books

***Please note all prices include postage & packaging***

**GRAND DAME: HOLLAND AMERICA LINE & THE S.S. ROTTERDAM**
By Stephen M. Payne FRINA
Stephen Payne, Naval Architect of modern day cruise ships, fully describes the Holland America line's flagship, S.S. Rotterdam, designed and built over thirty years ago and discusses her owners in his above mentioned book. Various chapters describe the building of the ship, her construction, her technical features, her passenger accommodation, and the Holland America line transition from Atlantic ferry to cruise ship operators.
**Price: UK £10.00 EUR £12.00 OVS £14.00**
**(NOT ON AMAZON)**

**IMPROVING SHIP OPERATIONAL DESIGN**
**Compiled By The Nautical Institute Ref: ISOD**
This book has been prepared to assist with the feedback from the user and is based upon a survey of the Institute's membership and the solutions advocated by experienced practitioners. The book is essential reading for all those involved in the design process whether in a shipping company, independent design office or shipbuilder. Also sea staff will understand more fully their essential role in communicating with design staff, particularly when standing by a new building.
**Price: UK £20.00 EUR £23.00 OVS £25.00**
**AMAZON PRICE: £26.25**

**LAMENTABLE INTELLIGENCE FROM THE ADMIRALITY**
**By Chris Thomas**
HMS Vanguard sank in thick fog in Dublin Bay in September 1875 rammed by her sister ship. No lives were lost (except perhaps that of the Captain's dog) but this one event provides valuable insight into naval history of the late nineteenth century. Chris Thomas examines what happened, setting it in the context of naval life, the social and economic situation of officers and ratings. He describes the furore caused by the unjust verdict of the Court Martial, vividly illustrating the joys and trials of the seagoing life in the Victorian era, and the tragic effect on the life of Captain Richard Dawkins and his family.
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**SD14: THE FULL STORY**
**John Lingwood**
The SD14 is almost extinct, and this book is a fitting tribute to a much-admired British designed cargo ship. Indeed, it should become the definitive history of the SD14 its derivatives. It provides a first-hand account of the SD14's conception and planning from a member of the design team, with many personal insights into the shipbuilding industry of the 1960s. Included are full career details of every SD14, the Prinasa-121s, the SD15 and the three SD18s: a total of 228 ships built wby seven yards in four countries. Every ship is illustrated, usually at several stages of its career, 99% in full colour.
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**SHIPS AND SHIPBUILDERS: PIONEERS OF SHIP DESIGN AND CONSTRUCTION**
**By Fred Walker FRINA**
Ships and Shipbuilders describes the lives and work of more than 120 great engineers, scientists, shipwrights and naval architects who shaped ship design and shipbuilding world wide. Told chronologically, such well-known names as Anthony Deane, Peter the Great, James Watt, and Isambard Kingdom Brunel share space with lesser known characters like the luckless Frederic Sauvage, a pioneer of screw propulsion who, unable to interest the French navy in his tests in the early 1830s, was bankrupted and landed in debtor's prison. With the inclusion of such names as Ben Lexcen, the Australian yacht designer who developed the controversial winged keel for the 1983 America's Cup, the story is brought right up to date.
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**THE ROYAL INSTITUTION OF NAVAL ARCHITECTS 1860-2010**
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**NOT ON AMAZON**

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**By John E Robinson**
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**August 13-15, 2013**
**Navalshore Brazil**, international conference, Rio De Janeiro, Brazil.
www.ubmnavalshore.com.br

**September 3-5, 2013**
**Baltexpo,** international conference, Gdansk, Poland.
www.baltexpo.com.pl

**September 3-6, 2013**
**Offshore Europe**, international conference, Aberdeen, UK.
www.offshore-europe.co.uk

**September 10-12, 2013**
**Contract Change Management for Ship Construction**, Repair & Design Course, course, London, UK.
www.rina.org.uk/conferences

**September 10-13, 2013**
**DSEI**, international conference, London, UK.
www.dsei.co.uk

**September 13, 2013**
**Marine Coatings Course**, course, London, UK.
www.rina.org.uk/conferences

**September 13-22, 2013**
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www.southamptonboatshow.com

**September 17-19, 2013**
**IBEX 2013**, international conference, Kentucky, USA.
www.ibexshow.com

**September 17-19, 2013**
**Advanced Model Measurement Technology for the Maritime Industry**, course, Gdansk, Poland.
E-mail: amt13@ncl.ac.uk
http://conferences.ncl.ac.uk/amt13

**September 18-21, 2013**
**MTB Workboats**, international conference, Athens, Greece.
www.coplandevents.com

**September 24-27, 2013**
**NEVA**, international conference, St Petersburg, Russia.
www.transtec-neva.com

**September 24-26, 2013**
**ICCAS 2013**, international conference, Busan, Korea.
E-mail: conference@rina.org.uk
www.rina.org.uk

**September 24-26, 2013**
**Seatrade Europe**, international conference, Hamburg, Germany.
www.seatrade-europe.com

**September 30 – October 2, 2013**
**Middle East Workboats**, international conference, Abu Dhabi, UAE.
www.middleeastworkboats.com

**October 7-10, 2013**
**PACIFIC 2013**, international conference, Sydney, Australia.
www.pacific2013.com.au

**October 8-10, 2013**
**INMEX**, international conference, Mumbai, India.
www.inmexindia.com

**October 5-9, 2013**
**Interferry**, international conference, Malta.
www.interferry.com

**October 8-10, 2014**
**OTC Brazil**, international conference, Rio de Janerio, Brazil.
www.otcbrasil.org/2013

**October 9-11, 2013**
**International Workboat Show**, international conference, New Orleans, USA.
www.workboatshow.com

**October 22-25, 2013**
**Kormarine**, international conference, Busan, South Korea.
www.reedexpo.com/en/Events/2671/KORMARINE

**October 28-30, 2013**
**World NAOE Forum 2013 & International Symposium on Developments in Marine and Offshore Renewable energy**, international conference, Minato-Ku, Tokyo, Japan.
www.rina.org.uk/MORE_symposium.html

**November 4-5, 2013**
**ML Ferries Conference & Expo**, international conference, Seattle, USA.
www.marinelog.com

**November 5-8, 2013**
**Europort Rotterdam**, international conference, Rotterdam, The Netherlands.
www.europort.nl

**November 12-14, 2014**
**Clean Gulf**, international conference, Tampa, USA.
www.cleangulf.org

**November 13, 2013**
**Deep-Ocean Science, Technology and Conservation 21st Century Opportunities and Imperatives**, Seminar, Hertfordshire, UK.
www.eeesta.org.uk/seminars.php

**November 19-21, 2013**
**METS**, international conference, Amsterdam, The Netherlands.
www.metstrade.com

**November 20-21, 2013**
**International Conference on the Design, Construction and Operation of Passenger Ships**, international conference, London, UK.
www.rina.org.uk/passenger_ships.html

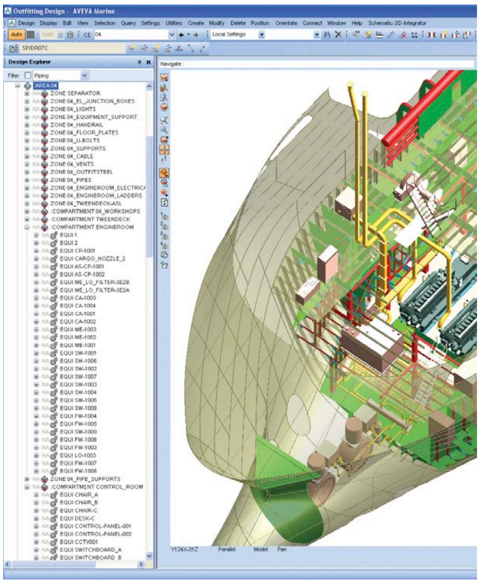
**December 3-6, 2013**
**Marintec**, international conference, Shanghai, China.
www.marintecchina.com

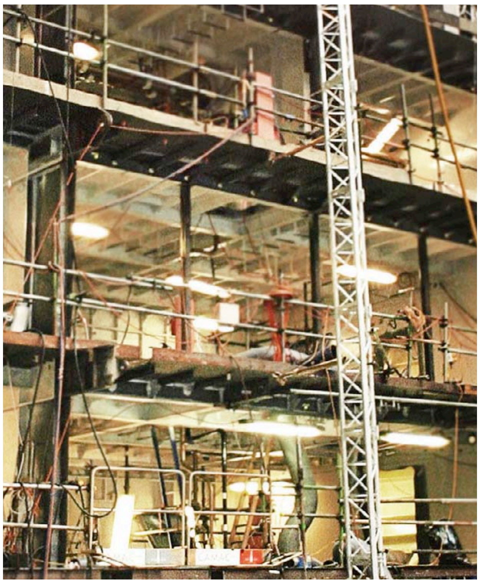
**December 4-6, 2013**
**International Workboat Show**, international conference, New Orleans, USA.
www.workboatshow.com

**December 12-13, 2013**
**ICSOT India**, international conference, Kharagpur, India.
www.rina.org.uk/ICSOT_india.html

**January 4-12, 2014**
**London Boat Show**, international conference, London, UK.
www.londonboatshow.com

**February**
**Vietship**, international conference, Hanoi, Vietnam.
www.vietship-exhibition.com



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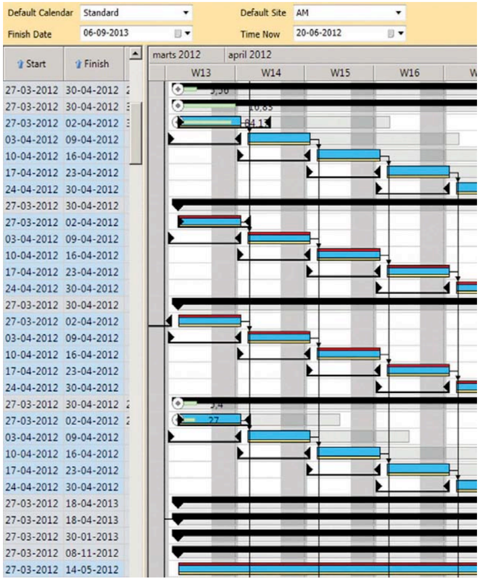

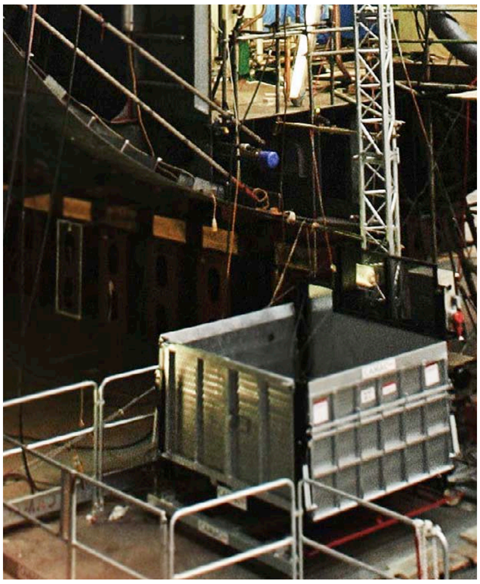
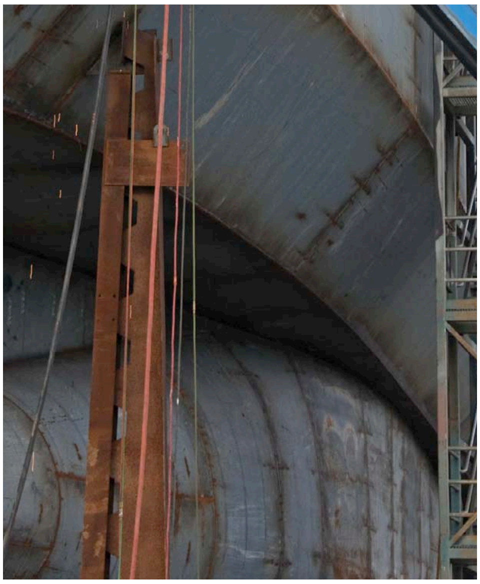

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Shipbuilders are facing an increasingly competitive market. Winning new contracts at your shipyard is about being able to rapidly adapt to the market, developing innovative new processes and providing the best value, best service and best products.

AVEVA's innovative Integrated Shipbuilding approach helps you meet this challenge, with the most complete solution for integrating all aspects of the shipbuilding process. Combining powerful engineering and design applications and a fully integrated planning, materials and production system, all specifically developed for the unique needs of the shipbuilding industry. Now you can make the right decisions and use the best tools to optimise your projects - shortening schedules, lowering costs and improving quality.

The leader in design, engineering and information management software for the process plant, power and marine industries, AVEVA invests in our customers' success through a global sales and support network in more than 40 countries.

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