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**Editor** Nick Savvides  
**Editorial Assistant** Robert Grisbrook  
**Design/Production Manager** Sandy Defraigne  
**Group Sales Director** John Payten  
**Assistant Advertising Manager** Valder Gates  
**Advertisement Production Manager** Stephen Bell  
**Subscriptions & Publications Manager** Josie Smith  
**Publisher** Mark J Staunton-Lambert

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 London, WC2N 5DA, UK  
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 Telefax: +44 (0) 20 7245 6959  
**E-mail editorial** editorial@rina.org.uk  
**E-mail advertising** advertising@rina.org.uk  
**E-mail production** production@rina.org.uk  
**E-mail subscriptions** subscriptions@rina.org.uk

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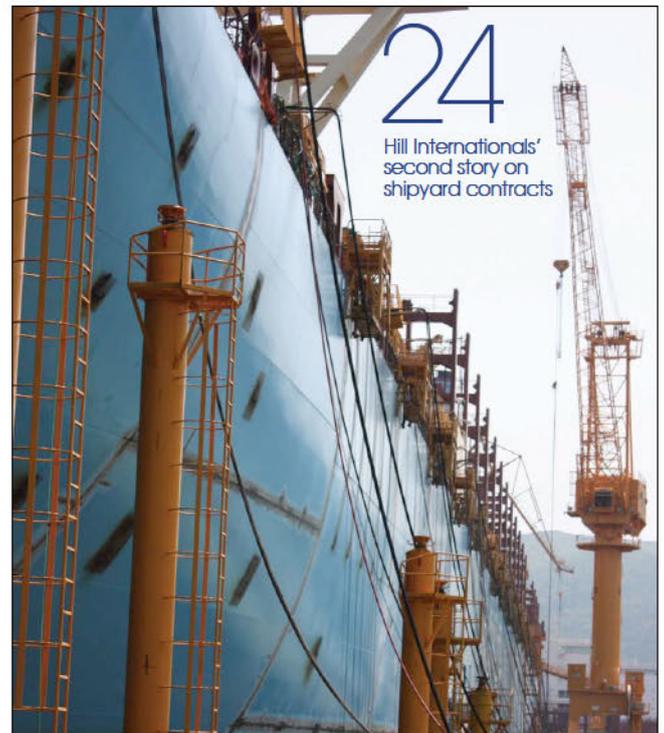
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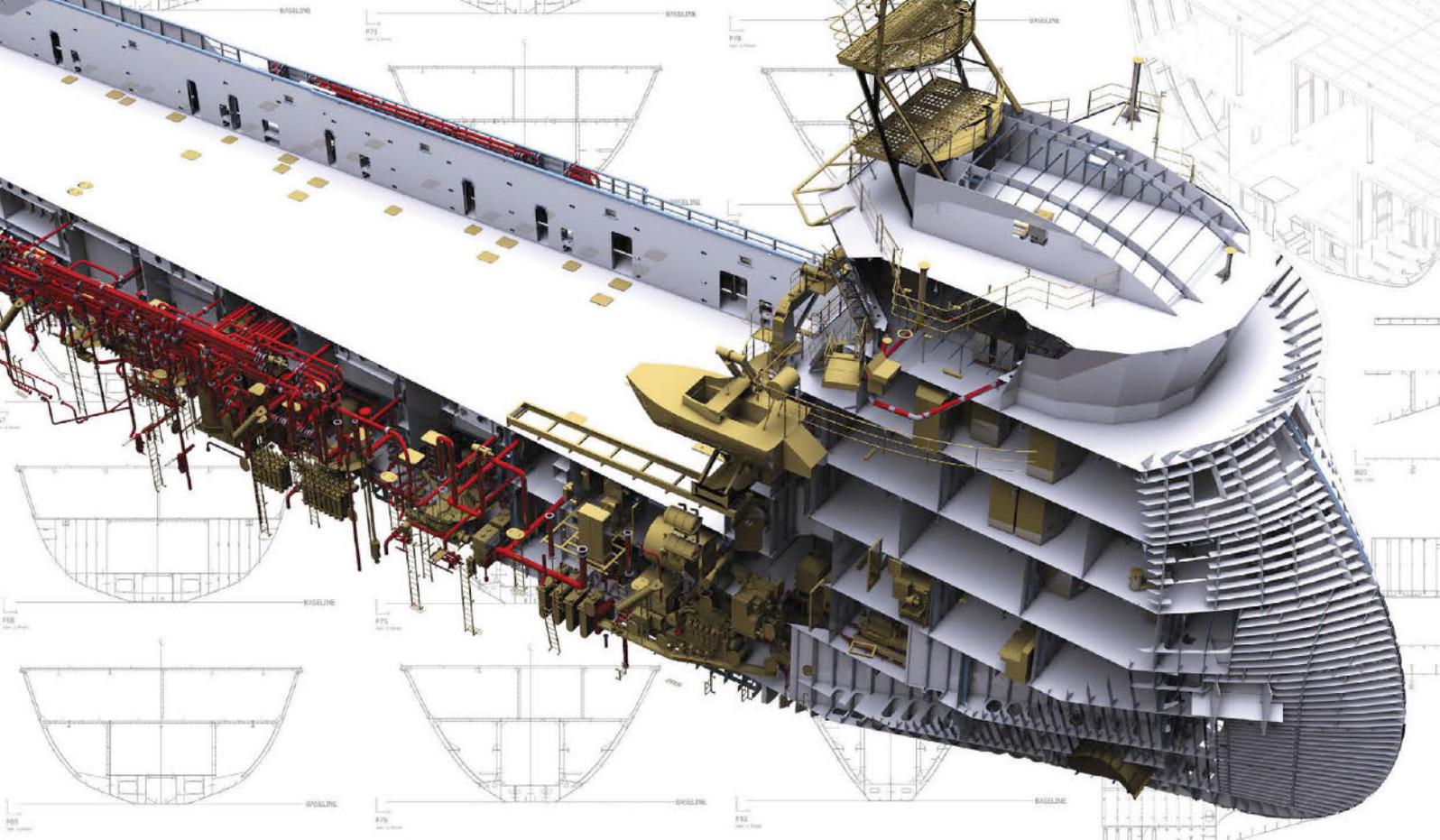
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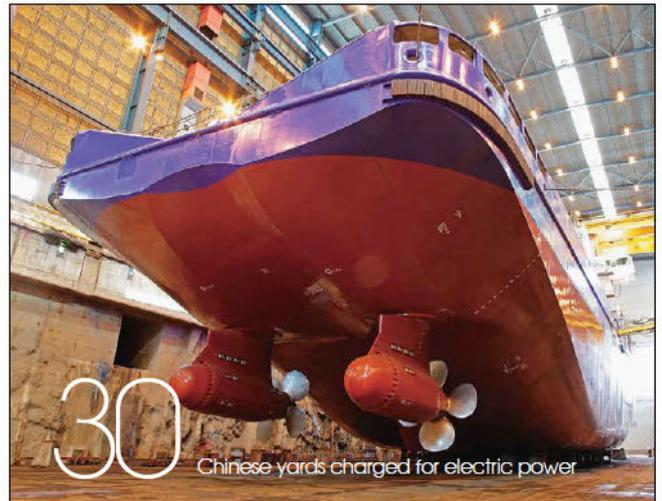
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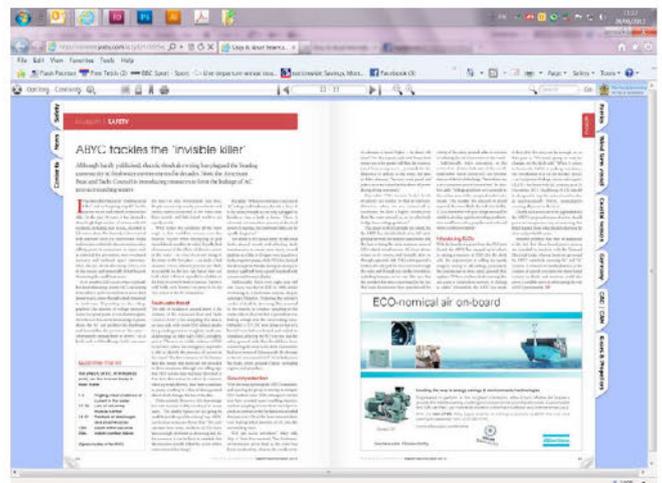
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**EUROPE:** Phone: +44 7939 468 224 Fax: +44 2891 240 138 Email: [p.rea@LSAMES.com](mailto:p.rea@LSAMES.com)

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## Yard preservation

A leaner, more robust ship-building industry will rise from consolidation

**T**he reduction in annual growth in China, the world's factory, from double to single figures is the most dramatic demonstration of the reduction in global consumer demand. Such a decline in demand is having and will continue to have a significant impact on shipping and shipbuilding.

With declining demand for consumer goods comes the obvious decline in demand for cargo space on ships, with the impact on shipbuilders, particularly in Korea and China, being a reduction in demand for new vessels.

Twenty first century economics, up to 2008, were constructed on debt; money borrowed by consumers on the notional value of property. In the US and Europe banks were lending increasing amounts of money to borrowers that could not repay the loans.

It was a Ponzi scheme that had to fail. In the post-apocalyptic economics there is talk of economies being re-balanced and in the west this would mean starting to produce consumables that others want to buy; to earn money rather than merely borrowing increasing amounts.

It is likely that the rebalancing of economies will mean slower growth when the recession ends. For shipping this means there will be idling of shipyards and almost certainly more closures as already indebted yards struggle to avoid receivership.

In South Korea some of the yards are attempting to protect each other, with Samsung attempting to prevent the closure of Sungdong. Financial institutions are also trying to save the industry. Banks have lent in excess of US\$50 billion to safeguard South Korean jobs.

However, it seems uncertain how long these yards can hold out before a revival in the global economy turns fortunes of the maritime industry. What is more it seems unlikely that shipbuilding demand will return to pre-recession levels even if economic activity returns. Furthermore, it seems likely that any major increase in vessel demand will be a gradual process, taking years rather than the sudden demise experienced at the outset of the recession.

On the plus side for this strategy, the Chinese are now deep into the process of consolidating and closing unprofitable, low quality yards operating with questionable safety standards. This is an important step, but the process will be long. China had in the region of 1,600 yards, according to the China Association of National Shipbuilding Industry (CANSI) and that level has now declined by more than 50%, the same organisation reports.

Even so many of the yards still operating in China are in direct competition with the small to medium sized yards in South Korea; these are the most vulnerable yards at the moment, but by no means the only yards in trouble.

It has also been suggested that the massive debt burden being carried by financial institutions such as the Korean Development Bank and the Export-Import Bank of Korea (Korea Eximbank) may itself put the continued trading of these banks into jeopardy. Political pressure on the Seoul government may be increasing the politician's wish to preserve jobs and manufacturing within the country; the economic realities may force the issue in the end.

Part of the political thinking will include not just the loss of shipyards and the part of the country's manufacturing base but also the knock-on effect that this is likely to have in related industries and regionally also. Many businesses rely on shipbuilding such as the manufacturers of marine equipment, not just engines and cargo ramps, but also small engineering firms such as air-conditioning, pipe makers and the like.

The contribution of these industries to the regional economies in which they operate could be a key factor for the local economies, and the loss of these jobs to competitors could see a harsh reality in hitherto affluent regions.

In effect the South Korean shipbuilding industry is currently undergoing a painful restructuring that is likely to see it eventually emerge from this lingering global recession as a far leaner, more robust, but ultimately more compact industry than was the case less than 10 years ago. *NA*

IACS

## ABS takes the chair at IACS

New International Association of Classification Societies (IACS) chairman Chris Wiernicki says that IACS must understand the complex issues around cyber security better.

Speaking to the press in London in mid-September Wiernicki said: "IACS needs to understand the complex systems and the interface between cyber systems, ships and offshore platforms. We will be dedicating resources to this project."



Chris Wiernicki took on the chairmanship of IACS in July and says that IACS will focus on Cyber systems security and goal-based standards during his year-long tenure

Wiernicki, who took up his position in July this year, added that the interface between man and machines was also critical and that there was a need to manage this relationship including which data is available, and how it is stored and handled.

"We cannot ignore the importance of the human factor in the [cyber] process," he said.

However, Wiernicki does not believe that there will be fully autonomous ships. "I don't see that there will be an unmanned ship going forward." He added: "I can't imagine a ship without a crew, how would you handle an oil spill?" Finally he concluded. "I wouldn't get on an aeroplane without a pilot," he concluded.

Technology

## Innovation: "You can't treat it as a side dish"

EMS Seven Seas is expecting autonomous and remote controlled ships to be a reality within five years and the company is restructuring its business to meet this new challenge.

The company, a supplier of provisions, technical equipment, spare parts and services to the marine and offshore sectors, announced its rebranding and redirection at IMPA London on 10 September, explaining that the company will be relaunched as Seven Seas and has set out a new business strategy with innovation at its core.

Managing director, Seven Seas Marine Spares, Darko Komarica, says that Seven Seas is investing in smart technologies and partnering technology specialists to evolve with the times. He believes that autonomous shipping will begin with small container vessels of around 2,500TEU which will have decreasing numbers of crew on board.

Seven Seas' CEO, Lars Rosenkrands adds: "Our new corporate identity reflects the changes we've been making to the company over the past year and is in line with what our customers are asking for. We are pursuing a strategy to deliver concierge-like services to our customers and position Seven Seas as the most innovative, agile, solutions-driven concierge in the maritime industry."

The change comes in response to a highly competitive business environment, and is part of a wider growth strategy that aims to position the company as the world's foremost supplier to the global maritime sector.

Seven Seas has separated its portfolio of products and services as part of this change, splitting them into five divisions: Ship Supply, Marine Spares, Stromme Cleaning Solutions, Wave Shipping port agency services, and Cubisol maritime IT solutions. This provides a more customer-focused structure, enabling a swifter response to customers' supply chain requirements, according to Rosenkrands.

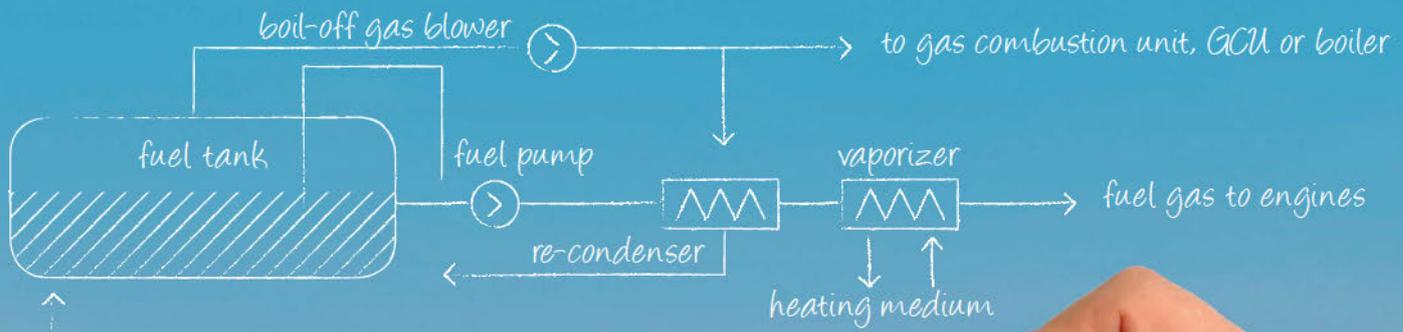
Komarica emphasised the need to be proactive rather than reactive when facing challenging economic conditions and technological advances. He says, "You can't treat it [innovation] as a side dish," it has to be integrated in all business aspects if you are to develop successfully.

Acquisition

## BV acquires design support co.

Classification society, Bureau Veritas, has finalised the takeover of HydrOcean, an engineering company that specialises in hydrodynamic digital simulation for the maritime industry.

The purchase stands to strengthen the service provision of Bureau Veritas, adding new technologies and expertise to its range of solutions that will reduce the risks and costs of the ship design process.



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CEO of Bureau Veritas, Didier Michaud-Daniel, says: “The acquisition of HydrOcean enables Bureau Veritas to integrate an outstanding team of experts and highly innovative entrepreneurs. The Group is increasingly developing solutions combining its core testing, inspection and certification services with new technologies. HydrOcean fits perfectly into this strategy thanks to its simulation tools and its technical expertise. Its services will complement those offered by the Marine & Offshore business, especially in reducing ship fuel consumption.”

HydrOcean provides design support for a number of marine sectors, including ship building, offshore structures and marine energy systems. It assesses and optimises hydrodynamic performance, and has co-developed advanced digital simulation tools in partnership with Ecole Centrale Nantes’ fluid dynamics laboratory.

The acquisition follows the success of a year-long commercial agreement between the two companies.

#### Smart ships

## One step closer to autonomous ships

Global mobile satellite communications services, Inmarsat, will partner Rolls-Royce on an autonomous ship project beginning this year.

The project, the Advanced Autonomous Waterborne Applications (AAWA) initiative, will research the economic, social, legal, regulatory and technological factors, bringing universities, research institutes, ship owners and other stakeholders together. It will build on existing ship-to-ship and ship-to-shore communication platforms and their effectiveness for supporting remote control functionality.

Inmarsat will deliver the vital satellite communications link and platform for the project through its Fleet Xpress service, the world’s first hybrid Ka/L-band mobile satellite system. Data transfer between ships and from ship to shore-based control centres forms the functional basis on which



autonomous ships operate, and so represents a core part of the AAWA initiative’s undertaking.

“Fleet Xpress will enable the ship-to-shore communications required to support the remote control functionality fundamental to the realisation of the autonomous ship. The high-performance, high-throughput network will open up unlimited possibilities for maritime applications and real-time monitoring and analysis of data, for smarter shipping today and the future,” says Ronald Spithout, president, Inmarsat Maritime.

The €6.6 million (US\$ 7.4 million) project is funded by Tekes (the Finnish Funding Agency for Technology and Innovation). It will be led by Rolls-Royce and is scheduled to end in 2017.

#### Regulation

## Regs demand product tanker changes

Product tankers that operate without upgraded oil discharge monitoring equipment will be ineligible to carry biofuels from 1 January 2016.

IMO Resolution MEPC.108(49), amended by MEPC.240(65), will subject biofuels to the same discharge rules as fossil fuel-derived oil cargoes, stifling trading opportunities for product tankers with outdated monitoring equipment.

Older vessels will be particularly affected by the new changes according to the managing director of Rivertrace Engineering (RTE), Mike Coomber. “On straightforward upgrades, all that is likely to be required is replacement of the measuring cell and installation of a new circuit board. You can do this work at sea and, with travel time, it’s likely to cost about \$10-12,000...But on pre-2005 units, you will basically have to start again. This could mean a new monitoring system, seven to 10 days’ sailing time for installation, and a bill of US\$30-40,000.”

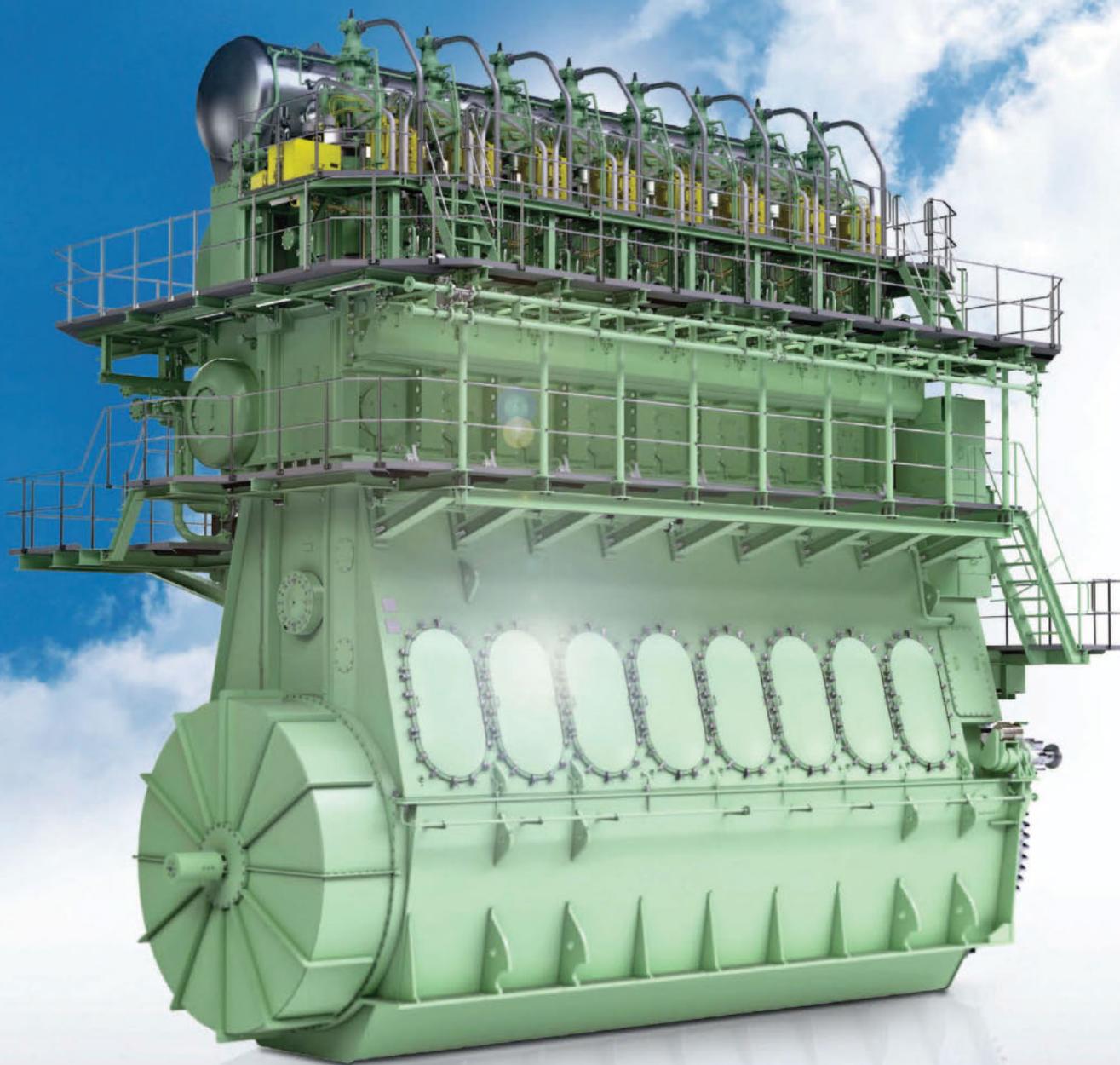
Current regulation governing the discharge of dirty ballast stipulates that tanker operators can discharge waste water in volumes of 30 litres per nautical mile provided the ship is travelling at more than seven knots, or up to 1/30,000 of the total cargo carried.

Coomber fears that tanker owners are “sleep-walking into a situation in which the employment opportunities for their ships will become seriously jeopardised,” following an RTE spot survey that found most owners were not aware of the new regulations. [NA](#)

Oskar Levander, VP - Innovation, Engineering & Technology, Rolls-Royce Marine (left), and Ronald Spithout, president, Inmarsat Maritime

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## Firing up ferry safety

Coming up with a safe and affordable ferry design is all the more important given the recent spate of accidents involving ferries which have cost the lives of many onboard, writes Sandra Speares.

Ferry accidents are nothing new, as has been demonstrated by casualties like the Philippine's *Dona Paz* in 1987 in which over 4,000 lives were lost. Ferry casualties like *Sewol* last year and *Dong Fang Zhi Xing* earlier this year, have both cost many hundreds of people their lives.

Many of the casualties of recent years have resulted from a number of factors, encouraging innovation in the area of ferry design, with the view of improving the safety of vessels. This is something that has evidently been of major importance to the Worldwide Ferry Safety Association over a number of years.

Stimulating the interest of the new generation has been an important part in the association's campaign. For the past two years, awards have been made to student teams of US\$10,000 annually, with the top prize each year being US\$5,000.

The competitions for 2013 and 2014, respectively, were to design a passenger ferry for the Bangladesh river system and for an inter-island ro-pax for Papua New Guinea. For 2015, the competition, with more streamlined requirements than the past, will be to design a ro-pax for Indonesia.

In spite of the authorities' efforts, ferry transport between islands lacks an adequate level of safety. Between 2000 and 2015, 37 accidents occurred in Indonesia, leaving 2,286 people dead or missing.

Casualties sadly continue and July saw the sinking of a ferry in the Philippines at a cost of at least 40 lives, which has given added urgency to calls for a probe of the maritime sector in an archipelago beset by similar disasters.

Ferries have always been a vital ingredient of transport between the country's islands, which number more than 7,000. The *Kim Nirvana* was the 14th major ferry accident in the country since 2000. The authorities are currently considering an investigation into the seaworthiness of the country's fleet, the experience of those handling the deployment of the vessels, and crew training to deal with casualty situations. Concerns have been expressed over whether the ship was overloaded or if modifications made to the ship had affected its ability to manoeuvre.

There have been a number of initiatives in recent times to improve ferry safety and to manage a crisis situation in the most effective way possible. For example, Italian classification society RINA has recently launched a ferry safety initiative, the Asset

Integrity Management scheme, which is aimed at ro-pax vessels covering such issues as fire risk mitigation, training, notably in how to avoid and manage a crisis, but also food and bacteriological risk management.

Fire on board ferries has been of increasing concern in view of a recent spate of accidents. One obstacle that needs to be overcome is the fact that fighting fires at sea is a demanding process and therefore much emphasis has been placed on preventative action ahead of a casualty situation, the need to minimise the spread of the fire, as well as protecting the crew who may face considerable risks, especially if the fire breaks out in an enclosed space like the engine room.

The use of halon for fighting engine room fires was banned several years ago for environmental reasons, but there are alternative gases available which are man-made and more user friendly than CO<sub>2</sub>, which is lethal for anyone in an enclosed space when a fire breaks out. In the case of chemical gas, "you should vacate the space before you put the gas in there, but if an accident did happen and somebody was in the space it is not life threatening. Chemical gases and inter gases are much less life threatening," says Roger Gundermann, technical manager of Wilhelmsen Ships Service's facility in Antwerp.

3M's Novec 1230 Fire Protection Fluid is an advanced, "next generation" clean agent halon replacement designed to balance industry concerns for performance, human safety and the environment, according to the manufacturers. Gundermann says that with a CO<sub>2</sub> system, regulations require it to be discharged within two minutes. With Novec the discharge is 10 seconds.

Lightweight panelled structural fire protection and other products including fibre reinforced polymer and such retardants will be put under the spotlight at Interferry's conference in Copenhagen.

Casualties like *Norman Atlantic* in December last year with the loss of eight lives have raised concerns about how fires on enclosed car decks can be extinguished given air flows onboard and the fact that the ship is underway.

There are a lot of big ro-pax ships where the top freight deck is a "shelter-deck" under the accommodation, ventilated naturally by very large apertures on either side and which could not be battened down in case of a fire. Even if the ship is stopped, the wind will continue to blow through these decks and make it difficult to suffocate the fire. On several of the designs the life boats or rafts are directly above the apertures, which mean that the boats or rafts may be inoperable. *NA*

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## Propellers

## World's first composite propeller guideline

ClassNK has released a new guideline on composite propellers that aims to assist in the effective use of composite material propellers on ships.

The guideline outlines a three-tiered manufacturing approval test, consisting of coupon, element and full-size testing, and features advice on the application of composite materials to the propeller; how to receive approval of the manufacturing process; and the range of testing/inspection to be carried out on the product.

Performance and quality are central to the guideline; it stipulates that "To apply a composite propeller including CFRP to ships, the material must have the required performance at least equal to the existing copper alloy castings, and it is necessary to confirm in advance that the composite propeller, as an industrial product, can be manufactured with uniform quality."

Composite materials such as glass fibre reinforced plastic (GFRP) and carbon fibre reinforced plastic (CFRP) offer a strong and corrosion resistant substitute of composites with a high copper content, an increasingly expensive and exhausted mineral. They are used in an expanding range of fields, including aerospace, automobiles and wind power generation.

The first CFRP propeller was installed on the *Taiko Maru*, a domestic 499 GT chemical tanker, in May 2014.

[www.classnk.com](http://www.classnk.com)

## Deck equipment

## Optimising storage

MacGregor, part of Cargotec, has developed a new storage system that will make better use of available deck space.

The 40ft flat rack system has been designed to maximise the capacity of storage bins, and comes in response to the weight reduction of twistlocks, stackers and midlocks, which can "often lead to the maximum volume of a storage bin being reached before its maximum payload," says Perttu Jokinen, lashing portfolio manager, cargo stowage and securing systems, MacGregor.

One flat rack can accommodate a total of 16 storage bins that are colour-coded for the organisation of different products. When one rack is fastened above another, the two racks have the equivalent dimensions of a high cube container (9'6"). This design allows for other containers to be loaded on top of it and the rack to be operated as a standard container.

Each flat rack weighs 2,500kg and has a maximum payload of 32,000kg.

MacGregor's new system meets ISO standards and has been approved by DNV GL according to the requirements of the international Convention for Safe Containers (CSC).

[www.macgregor.com](http://www.macgregor.com)

## Propulsion

## Low-voltage motor saves on fuel costs

CSBC Corporation, Taiwan, has chosen to use Siemens' diesel-electric propulsion system in four semi-submersible deck cargo vessels (SSDCVs) to be built at its Kaohsiung shipyard.

According to Siemens, the propulsion system offers better manoeuvrability when navigating at low speeds and is economical and energy-saving because of the low-voltage motors and frequency converters it uses, reducing fuel costs by 15% when compared with conventional mechanical propulsion technologies. This reduction is achieved with the help of power management features such as power plant protection, which ensures a higher availability of power through gen-set optimisation.

The company also offers ballast pump systems that aim to control and dispose of pollutants, protecting the environment.

Each propulsion system forms an integrated drive system, featuring four low-voltage 4,000kW Simotics motors and four low-voltage Sinamics frequency converters with corresponding transformers.

In addition, the scope of supply includes 6,980kW main generators, medium-voltage switchboards, power management systems, converters and transformers for ballast pumps as well as distribution transformers, a controllable pitch propeller, flap rudder, and a bow and stern tunnel thruster.

The 65,000tonne SSDCVs will be delivered to a client in Singapore by the end of 2017.

[www.siemens.com](http://www.siemens.com)

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SSI's CAD/CAM software ShipConstructor stores an array of data that can be leveraged in maintenance, repair and lifecycle support work.

The software utilises a Marine Information Model (MIM) which is centred on a complete virtual model of the vessel. This includes each engineering discipline, from hull production and design and structural detailing, to outfitting and assembly sequencing. As a result, ship design and re-design are consolidated and connected over the course of a vessel's lifecycle by a single interface and project database. The database stores the intelligence, relationships,



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attribute information, 3D model, and any rules and standards that were used in the composition of the product model.

As-built models (complete virtual models) can leverage the capabilities of ShipConstructor's MIM for lifecycle support. This approach can reduce repair costs and ensures that maintenance is more efficient, saving time.

The US Coast Guard has recognized the value of this approach, stipulating that ShipConstructor compatible programmes should be used in the modelling of its 11 new Offshore Patrol Cutters: "The 3D product model shall be provided in either ShipConstructor or an ISO 1030303 Step compliant system that is exportable to ShipConstructor."

[www.ssi-corporate.com](http://www.ssi-corporate.com)

#### Coatings

## Long-life protection for running gear

Subsea Industries, a Hydrex company, is offering a 10 year guarantee on Ecoshield, a coating product that prevents damage to running gear.

The coating can be applied at drydock or newbuild stage and is designed to protect rudders, thrusters, azimuth thrusters, azipods, thruster nozzles, Kort nozzles, thruster tunnels and other underwater ship gear that can suffer from corrosion and cavitation damage. Overcoatings can be applied in as little as three hours, allowing the two necessary coats to be applied in a single day.

The grassflake resin coating insulates the applied rudder or other part with its heavy glass content, "making cathodic protection systems including sacrificial anodes virtually unnecessary," according to the company.

A variety of vessel types have had their rudders coated with Ecoshield, including several container vessels, ro-ro vessels, a crude oil tanker and a multi-purpose offshore vessel.

[www.hydrex.be](http://www.hydrex.be)

#### Scrubbers

## Hybrid system on repeat order

Wärtsilä will provide a series of exhaust cleaning scrubber systems for three Finnlines vessels after the successful fulfilment of a similar order for six scrubber systems in 2014.

Finnlines, part of the Grimaldi Group, has chosen to order Wärtsilä's Hybrid in-line scrubber system because it allows for the flexible operation of both

open and closed loop modes, and offers a compact, space and weight saving solution.

"Repeat orders are always very satisfying as they represent confirmation that the performance of the systems delivered earlier fully meets the owners' needs and expectations... We [Wärtsilä] have a very strong track record in enabling ship owners and operators to comply with all SOx emissions regulations," says Juha Kytölä, vice president, environmental solutions, Wärtsilä.

The scrubber system cleans ship exhausts, enabling the continued use of heavy fuel oil, while also complying with the water discharge criteria set by regulators.

The equipment order will be delivered in early 2016.

[www.wartsila.com](http://www.wartsila.com)

#### Monitoring

## Tech dictated monitoring

Classification society DNV GL has worked with operators to combine online monitoring and analysis tools that will improve the output and longevity of inefficient rotating equipment.

The combined service consists of online condition monitoring that produces performance data, and reliability, availability and maintainability (RAM) analysis, which seeks to explain the causes of mechanical shortfalls and failures.

"Rotating equipment can be attributed to 90% of production losses. Typically, those losses can affect 5-10% of production assuming production averages 50-150 million barrels of oil per annum and an average cost per barrel is US\$53. The average loss would be US\$140-420 million per year, a saving of just 1% in this area would be in the order of US\$1.4-4.2 million," says Chris Dagnall, manager, rotating machinery group, DNV GL.

According to DNV GL, the information produced from the tools allows operators to optimise maintenance strategies and can be quantified to improve costs and quality. Its ability to aid decision-making, such as on whether to replace or repair equipment, or how many spares to keep, is key to this process.

Director of division Europe & Africa, DNV GL, Liv Hovem, says: "Condition based monitoring, combined with RAM analysis is essentially a strategy that uses the actual condition of the asset to decide what maintenance needs to be done. This method dictates that maintenance should be performed when certain indicators show signs of decreasing performance or upcoming failure. Essentially, it targets improvements in the right place at the right time."

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Mooring

## TTS wins boxship order

The German division of the TTS Group secured a contract to supply anchors and mooring winches for the 11 container vessels of 20,000TEU each on order at Daewoo Shipbuilding & Marine Engineering (DSME).

TTS's Bremen-based company will manufacture the equipment at its Korean factory and deliver it to the yard over the next two years. The company also supplied similar equipment for the 20 original E-Class vessels delivered in 2014. Options for another six of the 400m long 58.6m beam ships are available, says Maersk.

However, as a consequence of the challenging market situation in the offshore sector another subsidiary, TTS Offshore Solutions based in Norway, has decided to temporarily lay-off 40% of its staff, with 30 full-time workers laid off and another 20 contracted out to other TTS divisions. The laid off staff work mainly in Norway and Poland.

[www.ttsgroup.com](http://www.ttsgroup.com)

Monitoring

## Oil mist detector gets green light

Quality Monitoring Instruments (QMI) has received type approval certification from Lloyd's Register (LR) for its engine oil mist detection system.

This certification follows the successful calibration testing of QMI's Multiplex and Triplex products in accordance with the stringent IACS M67 protocol.

"The IACS M67 rule specifies the parameters for crankcase oil mist detection equipment in diesel engines. They are exceptionally complex calibration tests, so we are delighted to have received type approval from LR. The tests verify the functionality and effectiveness of our Multiplex and Triplex systems in detecting oil mist concentrations of between 0.05 and 2.0mg/l to an accuracy of  $\pm 10\%$ ," said Josh Smith, QMI managing director.

The UK-based manufacturer received ABS type approval in 2014.

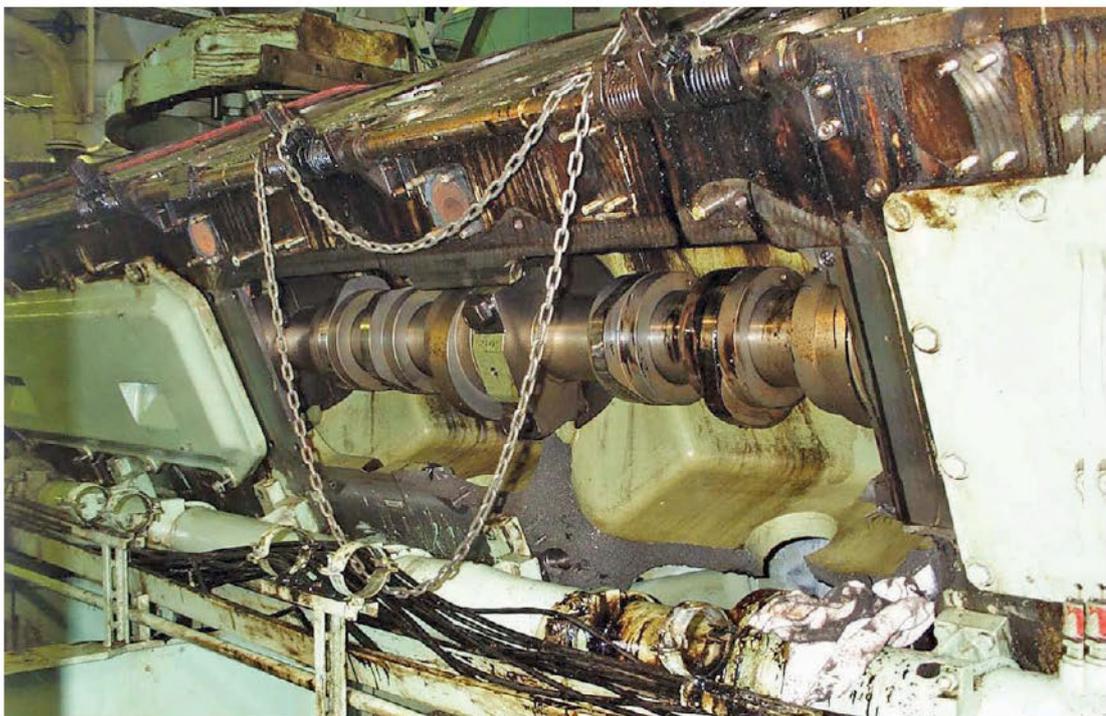
According to the company, QMI is the first manufacturer of oil mist detection equipment to use Nephelometry to detect escaping oil mist. Nephelometry, which is also used in medical operations, is a light scatter technology that allegedly promises 100% alarm reliability and an immaculate safety record.

"Conventional oil mist detectors are susceptible to spurious alarms and respond slowly to oil mist changes...These systems are [also] proven to be ineffective when monitoring the upper part of a crankcase, and early stage wear and tear is not detected, resulting in an increased risk of an oil mist fire," adds Smith.

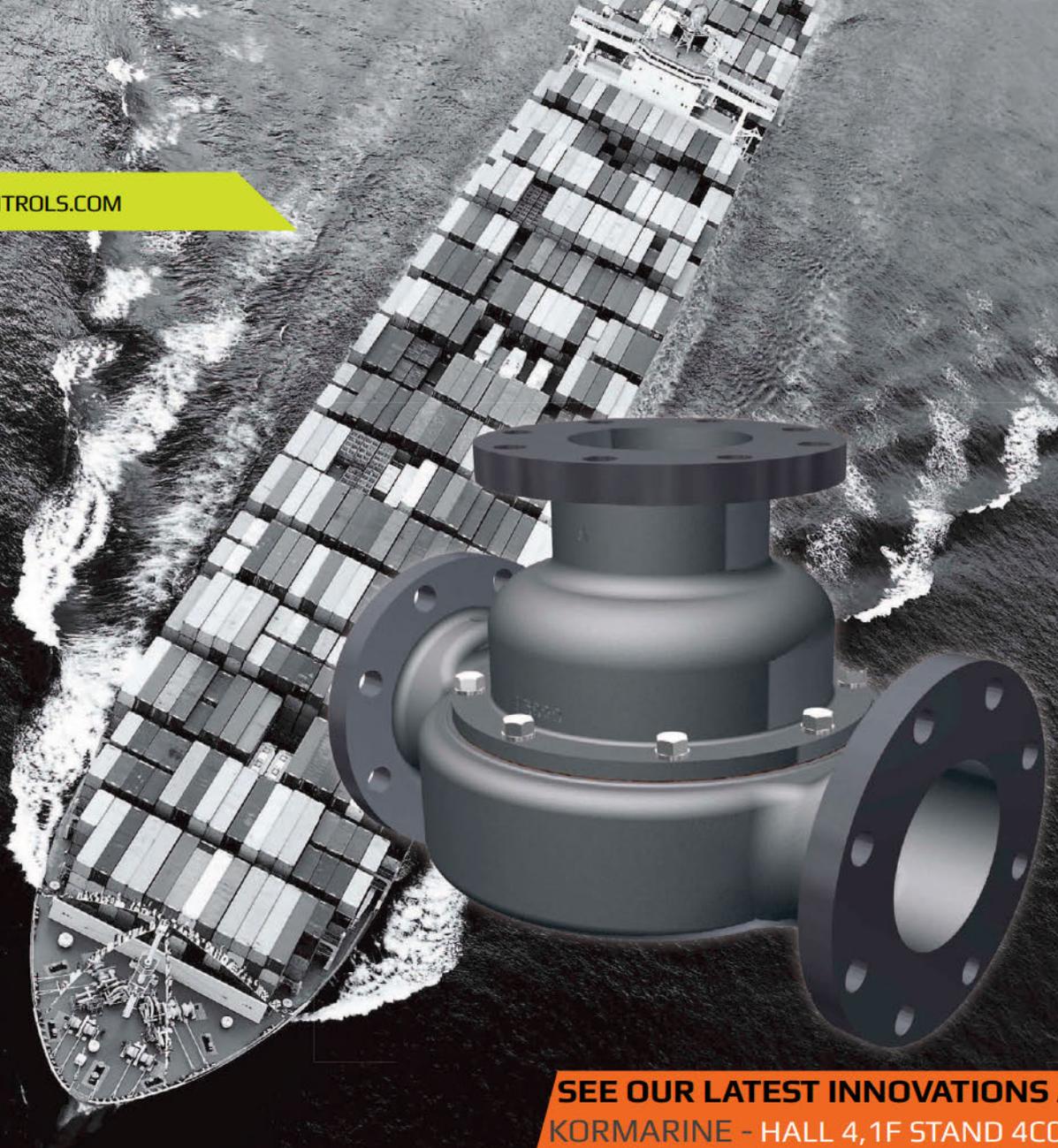
Escaping oil mist has been linked to roughly 65% of machine and engine room fires at sea.

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# It's a confidence thing

In today's changing world of oil & gas maritime confidence plays a key part in the industry; but how does confidence, or lack thereof, affect employees? Maritime and offshore recruitment specialist Faststream Group CEO, Mark Charman, investigates how confident naval architects are about their current and future prospects

In October 2014 Faststream wrote in *The Naval Architect* that the oil & gas market was booming and how some naval architects were making the move away from their traditional roles in maritime and into the lucrative world of oil & gas. Times have changed and what was becoming a trend last year has been turned on its head.

As a recruitment business Faststream speaks to candidates every day about what they want to do and why they want to move. Confidence plays a key emotive part of the recruitment process and on many occasions an employee will leave a job based on the confidence in their company, their sector or their manager. For naval architects looking for a new role there are good opportunities available. Companies are still looking for talent and today this talent is not just walking the street. There have been no mass redundancies and where some areas of the market are clearly struggling there are pockets of other areas which are booming.

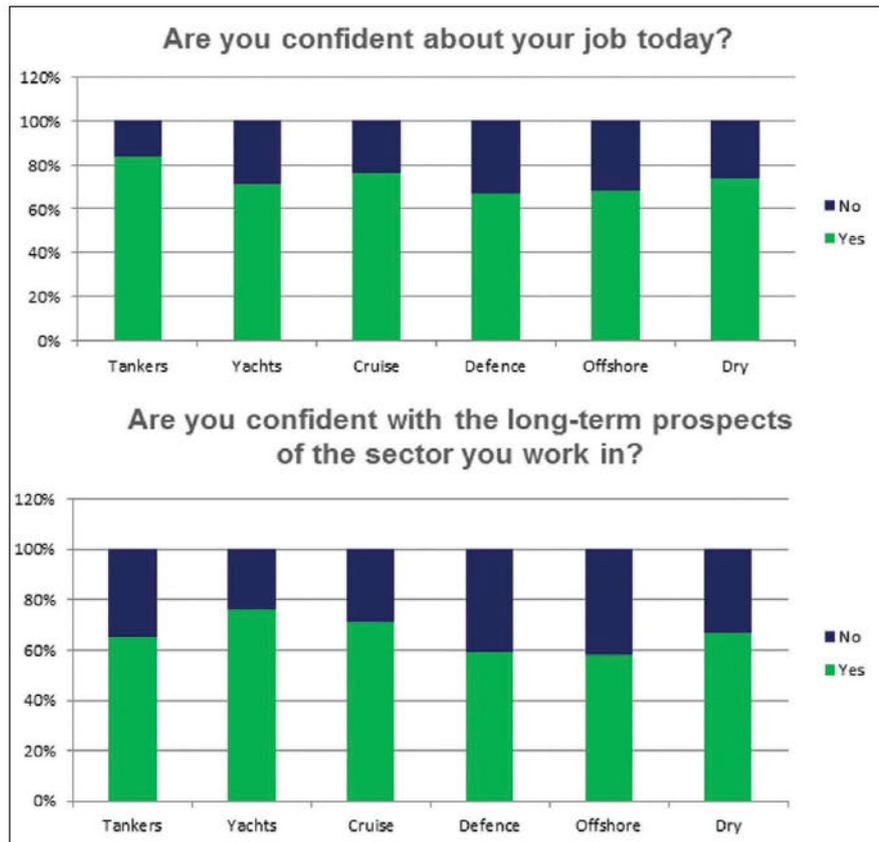
So just how are naval architects really feeling? As a recruitment company we were in a position to ask our clients and we conducted a detailed confidence survey of over 7,000 naval architects in September 2015, to establish how people felt about their job, the long terms prospects of the sector they work in, and how prepared they would be to move away from their comfort zone, if times get hard.

## Your job today

70% of naval architects surveyed indicated that they are confident about their job today which was consistent across the majority of sectors and employer types. Those working for class societies or in the tanker sector



Mark Charman, CEO, Faststream Group

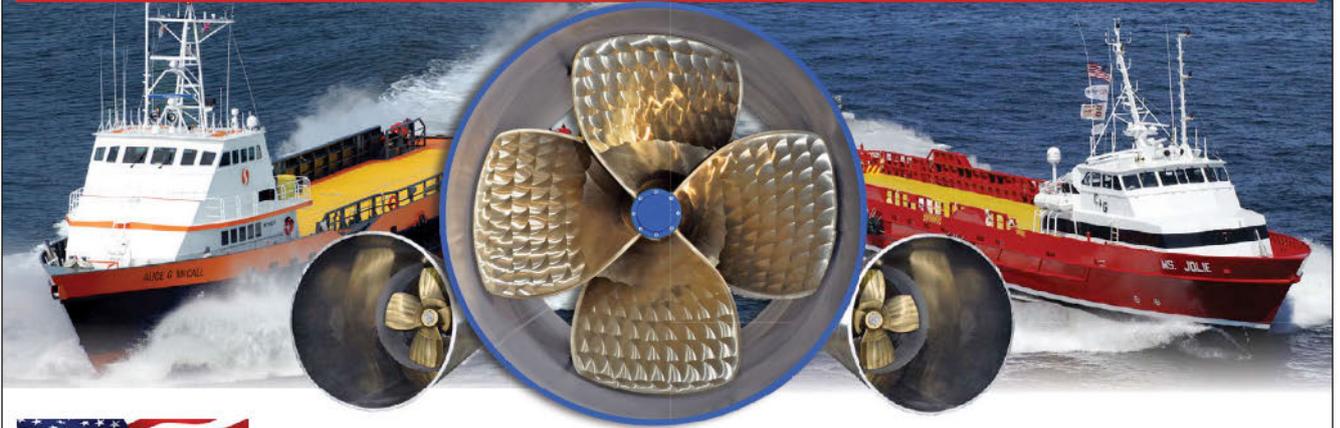


Data sourced from the Faststream confidence survey of over 7,000 naval architects in September 2015



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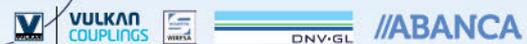
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were stand out when it came to confidence in their roles with 85% and 84% respectively confident about their job today. Unexpectedly the offshore sector was second to defence when it came to low confidence levels.

Whilst much is written about the on-going cuts in government spending and the decrease in new-building projects for export internationally, this is generally a stable sector for naval architects and with long-term projects in place, should provide employees with good prospects for years to come.

For the 30% of naval architects concerned about their immediate prospects it's interesting to see how these people would be willing to adapt their employment terms to improve their prospects. Those who are not confident about their job today overwhelmingly choose working on a contract basis above relocation and the least favourite, a change of sector, to improve their prospects. Whilst naval architects and the offshore sector were early adopters of contract or project work, the same can't be said for those working in class societies or consultancies. These employers have traditionally followed the permanent recruitment model, but this is changing. They are on the look-out for contract and project based employees who can plug immediate gaps in their hiring and our survey proves that candidates are thinking alike.

Contract or project work provides employees with exposure to sectors or technologies that they would perhaps be unable to work in as a permanent member of staff, offers job diversity and often better pay. Clearly job security does not match that of a permanent role, but there are plenty of

contract and project roles available and good people will be able to move from project to project. It's also a good way into companies who aren't currently recruiting permanent staff, but will do so in the future.

However, there is another consideration for naval architects who want to take up project work. Our results show that relocation was second choice when it came to improving prospects, but most project roles will be in a diverse range of locations, which was not the natural choice for naval architects. An example of a project vacancy Faststream are working at the moment is starting in Copenhagen and then going with the project to China. Naval architects may need to emulate maritime professionals from a seafaring or operational background who typically have a more mobile attitude towards their job and career. An important point is that in today's world job security comes not from being employed but being employable.

Although employees named a 'change in sector' as their last resort to improve prospects, there are in fact opportunities to be had. The tanker and cruise sectors are good examples of employers who are broadening their horizons to bring in naval architects with experience of different ship types.

### Future prospects

Whilst it is easy to analyse employees' current positivity and negativity about their job, long-term prospects are often more difficult to conclude, especially with market conditions experiencing huge volatility. Faststream asked naval architects if they were confident about the long-term prospects of the sector they

work in, with 63% saying yes. When we talk about long-term in recruitment terms, we're really only talking about 1-3 years and like many sectors in oil & gas and maritime, naval architects are not protected from uncertainty within the market. In a basic conclusion 37% of naval architects are telling us that they aren't confident in their sector over the next 1-3 years and would consider a change of scenery.

Class societies again topped the polls of long-term confidence with 74% of employees comfortable with future prospects of the sector, followed by those working for owner/operators, consultancies and in last place shipyards where only 57% of their employees had long-term confidence. The fact is that retention of staff will be difficult for shipyards with long-term confidence levels low. As employers they'll need to do more to retain their staff or risk losing them to other areas of the market.

So is the employment market for naval architects good or bad? It depends where you're looking at it from. There's lots of unrest across the energy life cycle and naval architects are not immune from this. There will be employees who ride out the storm and those who will jump ship and that's normal. But do I see naval architects struggling for work? No. There is still demand for the best people, and although the length of the recruitment process will extend in the short-term, hires are and will still be made. The biggest change I believe will be in more non-traditional employment terms. There is a high demand for contract labour in areas of this market which needs to be embraced by employees and employers alike. **NA**

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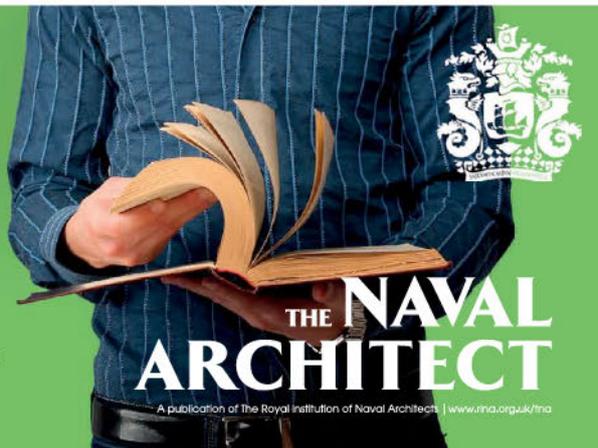


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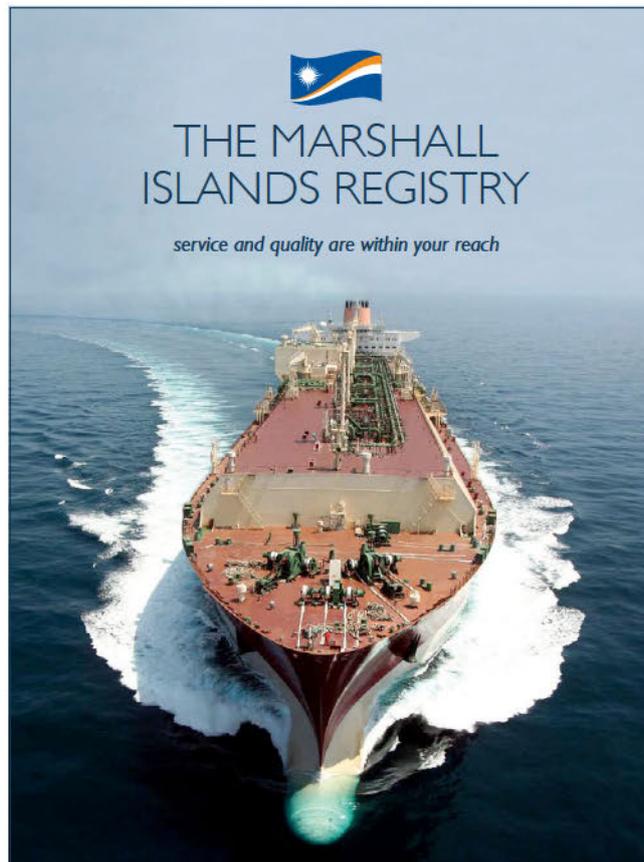
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# Analysing delays

In the second of David Price's three stories on contracts he looks at the commonly used techniques to Analyse Project Delay: As-Planned compared with As-Built Programme Analysis; As-Planned Impacted Analysis; Collapsed As-Built Programme Analysis; Time Impact Analysis and Windows Programme Analysis; Critical and Non-Critical Delays and Validation of Baseline Programme

**T**he forensic analysis of delay is important as a tool to ascertain the extension of time due to a builder if delivery of the vessel is late or alternatively the extent of liquidated damages payable to the buyer.

It refers to the investigation of events using Critical Path Method (CPM) or other recognised schedule calculation methods designed to demonstrate the effect of specified events on the progress and completion of the vessel. It relies on professional judgment and expert opinion and usually requires a number of subjective decisions to be made on the part of the analyst.

The most important of these decisions is what technical approach or methodology should be used to measure or quantify delay and to identify affected activities to focus on causation, and how the analyst should apply that chosen method.

There are a few tests which must be satisfied for a delay to be considered for relief from liquidated damages and compensation in respect of delay related damages.

Firstly, the delay must be shown to be critical, by reference to a reliable critical path analysis. Secondly, the party claiming damages must be able to demonstrate that they were not responsible for any delays which were concurrent with those critical delays being relied upon. Thirdly, the critical delays relied upon must be found to be excusable and compensable events under the contract.

## Basic principles

At any given point in time on projects, certain work must be completed at that point in time so the completion of the vessel is not further delayed. The industry calls this work, "critical work". Project circumstances that delay critical work will extend the project duration. Critical delays are discrete, happen chronologically and accumulate to the overall project delay at vessel completion.



David Price of Hill International says that an analysis of shipbuilding delays is an important tool for assessing any liabilities

When the project is programmed using CPM scheduling, the schedule typically identifies the critical work as the work that is on the "longest" or "critical path" of the schedule's network of work activities. The performance of non-critical work can be delayed for a certain amount of time without affecting the timing of project completion. The amount of time that the non-critical work can be delayed is "float" or "slack" time.

CPM scheduling facilitates the identification of work as either critical or non-critical. Thus, at least in theory, CPM schedules give the delay analyst the ability to determine if an event delays the project or if it just consumes float in the schedule. For this reason, delay evaluations utilising CPM scheduling techniques are now preferred for the identification and quantification of project delays.

The critical path and float values of uncompleted work activities in CPM schedules change over time as a function of the progress (or lack of progress) on the critical and non-critical work paths in the schedule network. For this reason, only project circumstances that delay work that is critical when the circumstances occur extend the overall project duration. Thus, when quantifying project delay, schedule analysts must evaluate the impact of potential causes of delay within the context of the schedule at the time when the circumstances happen.

## Creating the baseline schedule

It is preferable if before analysis is commenced, that the baseline or starting position is established. This is a crucial matter to get right because it is the foundation of any subsequent successful delay analysis (apart from the 'collapsed as-built form of analysis') and if it can be undermined, so too will be the subsequent analysis.

It is likely that even the most complete programmes will require some modification for a robust analysis. The courts have found that the "foundation" programme should be the original programme subject to justification and substantiation of its validity and reliability as held in *Balfour Beatty v Lambeth LBC* (2002). To establish a reliable baseline for the analysis, the objective is to remove flaws in the original master programme.

## Choosing a delay analysis method

There are a number of qualitative reasons, beyond pure technical schedule analysis reasons (considered later) that should be borne in mind in deciding which forensic schedule analysis method is to be used for a particular claim. The following eight factors should be factored into the decision as to the most appropriate method of analysis to adopt:

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**1. Contractual Requirements**

When a project is executed under a contract which specifies or mandates a specific schedule delay analysis method, then the choice of methodology is largely taken out of the hands of the analyst and contract compliance is the prevailing factor. However, even when the contract is silent on methodology, contract language may still constrain the delay analyst's choice of methods.

**2. Purpose of Analysis**

With respect to a particular project, the purpose of delay analysis is to determine which party is entitled to time extensions as a result of certain events. Once the delay analyst has assessed the events that occurred on the project then consideration must be given to issues such as concurrent delay, pacing delay, delay mitigation, etc. If the delay analyst, for example, is investigating whether concurrent delay is a major factor in the analysis of project delay, then the choice of method will be limited to those methods, which specifically provide for concurrent delay identification and analysis.

**3. Source Data Availability and Reliability**

The choice of a particular forensic scheduling methodology is substantially influenced by the availability of source data which can be validated and determined as reliable.

**4. Size of the Dispute**

One of the primary factors the delay analyst must keep in mind is the size of the dispute or the amount in controversy. In most situations, the choice is constrained by how much a client is prepared to spend to increase the probability of successful resolution of the dispute.

**5. Complexity of the Dispute**

When considering a delay analysis method, the delay analyst must do so with some knowledge of the complexity of the dispute in question and the number of events to be included in the forensic scheduling effort. For example, if the project in question is a linear project of relatively short duration and only three specific delay events need to be considered, then a simple comparison of the baseline with the as-built schedule may be appropriate.

**6. Budget for Delay Analysis**

Hand in glove with the size and the complexity of the dispute is the client's budget for the delay analysis.

**7. Time Allowed for Delay Analysis**

There may be occasions when the amount of time available to perform and produce a complete delay analysis is limited.

**8. Legal or Procedural Requirements**

Depending upon the forum for the dispute and the jurisdiction, the delay analyst must be aware of or ask about any contractual, legal, or procedural requirements that may impact the forensic analysis.

The analysis relies on the creation of the "As-Planned" and "As-Built" programmes which are then compared. This type of analysis fails to demonstrate what actually caused the delays and why they were caused. It takes no account of concurrency and fails to identify causation; this method only really facilitates a subjective interpretation of why there was a delay.

**As-Planned Impacted**

This type of prospective analysis is also relatively straight forward to produce. It provides a good illustration of cause and effect of each delay. However, it relies on the continuing relevance of the

**As-Planned v As-Built**

As far as the technical methods of delay analysis is concerned this is the least expensive methodology to adopt, but as a result it only produces simplistic results.

Analysing delays in ship building contracts requires a fact-based approach that can measure the impact of any delays says David Price



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“As-Planned” programme and produces theoretical results.

This method starts with the “As-Planned” programme and modifies the programme with delaying events. The events should be impacted sequentially and the programme rescheduled after each event. The outcome is a programme which incrementally identifies the effects of delaying events upon the completion date.

This type of analysis has some fundamental limitations. Firstly, the continued use of the “As-planned” programme fails to take account of changes to the critical path which would have occurred as a result of, *inter alia*, variations, progress of the works, additional works and changes in the methodology. Therefore, the “As-planned” programme is not the programme which is relevant to the claimant’s position at the time of any of the impacted events. Indeed the later the event the lower the correlation between the as-planned programme and reality.

Secondly, the impacts predicted by the “As-Planned” impacted methodology are an objective assessment of the likely effects of the event, rather than the actual effect resulting in a highly theoretical result. The “As-Planned” impacted methodology takes no account of the Builder’s acceleration or dilatoriness during the progress of the works in calculating the completion date. Instead it merely looks objectively at what is generally regarded as being the effect of change on the Builder’s intended method of working.

### **Collapsed As-Built**

This method starts at the completion of the project with the “As-Built” programme and works backwards, removing the delays from the “As-Built” programme sequentially with the intention of illustrating the extent of the delay caused by each event. It does not require a baseline programme but does require a detailed logic-linked As-Built programme. The methodology works by determining the “As-Built” programme from the records and then collapse out the claimant’s then the respondent’s defaults to gauge their effects. The results will then indicate the date when the works could have been completed “but for” the delays of either party.

This method has significant drawbacks. Firstly it can be quite difficult to accurately establish the “As-Built” programme; not

in terms of when the various activities were completed necessarily, but the proper dependencies between activities. There are two further limitations of this type of analysis: The “As-Built” critical path is likely to be very different from the actual contemporaneous critical path; therefore, delays identified may not have been a source of delay at the time when they occurred.

### **Time Impact Analysis**

This method determines the critical path contemporaneously and the delay impact is determined prospectively. It requires a logic linked baseline programme and update programmes or progress information with which to update the baseline programme and a selection of delay events to be modelled to assess the prospective impact that delay would have on predicted completion dates. A drawback with this method is that it does not detail the eventual actual delay caused by the delay event as subsequent project progress is not considered in this form of analysis.

### **Windows Analysis**

There are two methods of windows analysis, namely time slice windows analysis and As-planned versus As-built windows analysis.

The time slice windows analysis is first considered. This method requires the delay analyst to verify or develop a series of baseline programmes or contemporaneous programmes which accurately set out the status of the project at various snapshots (by way of time slices) throughout the project. These windows are usually at monthly intervals. Following the production of these windows the critical path will be revealed in each monthly period (or window) and the critical delay status at each time slice which allows the delay analyst to identify the extent of critical delay incurred in that month. The analyst next examines the project files to ascertain what events may have caused the critical delay in each window.

The “As-planned” versus “As-built” windows analysis method is next considered. This method is adopted when there is doubt over the validity or reasonableness of the baseline and/or updated programmes and/or where there are few contemporaneous programme updates. This situation can be faced in many projects. This method does not substantially rely on planning software

and the analyst applies common sense to practically analyse the facts to determine the critical path. The extent of the critical delay is then ascertained by comparing key dates along the critical path against the corresponding planned dates in the baseline programme. Finally, the delay analyst then examines the project files to ascertain what delay events may have caused the identified critical delay.

### **Summary**

There is clear guidance from the Society of Construction Law Protocol (published initially in 2002 and revised recently in July 2015) that a fact based approach to measure the impact of delay retrospectively is the preferred technique to resolve complex disputes related to delay and compensation.

What can be drawn from the principal cases that have dealt with delay analysis approach and methodology are the following clear principles.

Firstly, the analysis must primarily be a factual one that shows what actually happened, so that the events and their effects should be examined at the time they occur in the context of the work actually going on at the time as held in *McAlpine Humberoak Ltd v McDermott International Inc. (No. 2)* (1992) and *Henry Boot Construction (UK) Ltd v Malmaison Hotel (Manchester) Ltd* (1999).

Secondly, in order to establish that an event has affected the completion date, it must be shown that it falls on the critical path as held in *Henry Boot Construction (UK) Ltd v Malmaison Hotel (Manchester) Ltd* (1999) and *Motherwell Bridge Construction Ltd (t/a Motherwell Storage Tanks) v Micafil Vakuumtechnik* (2002).

The analysis should be proportionate to the purpose for which it is being carried out but should always be factually based and accurately reflect what happened on the project, anything else is likely to be dismissed as a theoretical exercise that fails to demonstrate entitlement; the former is the whole purpose of the exercise. **NA**

### **Author**

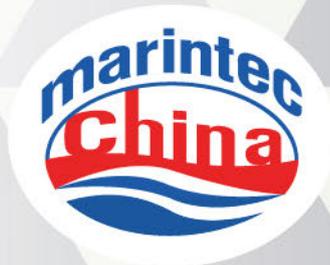
David Price BSc (Hons), LLB, DipArb, FRICS, FCI Arb, Barrister  
Senior Vice President of Hill International  
davidprice@hillintl.com



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# Ramping up electric power R&D

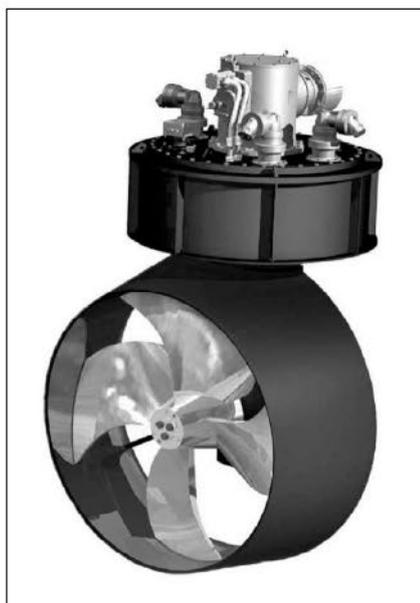
Wencheng Jiang and Wenbo Chen, China Shipbuilding Economy and Market Research Center, report on China's emerging marine electric power industry

In an electric propulsion system, a generator is driven by a primer to generate power; the power is then used to drive the motor to move the propeller.

Compared with the traditional propeller directly driven by diesel engine, electric propulsion systems have a series of advantages. They help improve the controllability of the vessel, save deployment space, lower noise levels, reduce pollution, and improve safety.

Thanks to these advantages, electric propulsion systems have gained popularity in shipping in recent years and are widely applied on ice-breaking vessels, dredgers, offshore supply vessels, ferries, and luxury cruise ships.

China Shipbuilding Industry Corporation (CSIC)'s No.712 Research Institute specialises in the R&D of different parts of ship electric propulsion



Siemens' SISHIP electric propulsion system



systems, such as system integration, motor, electric switches, electronics and control. The institute has always been in a leading position in China, from the early stage's direct current (DC) propulsion to today's fully integrated alternate current (AC) propulsion.

Fully rotational/all-direction propeller by Germany's ZF Friedrichshafen AG

All electric propulsion systems installed in existing and newly-developed vessels in the Chinese navy are supplied by the institute. In 2011, the institute set up a laboratory for 20MW electric propulsion systems in Qingdao. The laboratory will be upgraded to cater for the R&D of 40MW electric propulsion systems in the future.

The institute is the first integrator in China to receive orders for electric propulsion systems. In 2008, an electric propulsion system compiled by the institute was installed on the "Beidiao 991" small waterplane area science survey vessel built by Wuchang Shipbuilding Industry Group Co Ltd, stopping the monopoly by foreign suppliers in the area.

In 2009, the institute won an order from Japan's Mukaishima Dock Yard Co Ltd for its GT499T bulk carriers, beating well-known international electric propulsion system integrators such as ABB, Siemens and Converteam and making the debut of Chinese integrators in the international market.

In 2013, the institute compiled an electric propulsion system of normal rating of 20MW or below with a single shaft that is solely built in China. Up to now, the institute has supplied electric propulsion systems to a number of locally owned vessels, including bulk carriers, survey ships, cruise ships, and cable laying vessels.

The Shanghai Marine Equipment Research Institute (SMERI) also known as CSIC's 704 Research Institute, is one of the pioneers of R&D in electric ship propulsion systems. It has three premises for R&D, primary and advanced testing; as well as two ship power system laboratories that can test power systems of electric propulsion vessels of below 12MW. The institute provides full life cycle services for electric propulsion systems including

Physical performance parameters	China Shipbuilding Industry Corporation CS21/32	Hyundai Heavy Industries H21/32
Cylinder diameter (mm)	210	210
Stroke (mm)	320	320
Engine speed (Cycle/minute)	1000	1000
Mean effective pressure (MPa)	2.5	2.2
Power per cylinder (kW)	210	210
Specific fuel consumption (g/kWh)	185	187
Weight (tonne)	19.0	18.4
Emission	NOx complies with IMO Tier II	NOx complies with IMO Tier II

Table 1: Comparison of physical performance parameters of typical domestic and overseas medium speed engines

Physical performance parameters	Shanxi Fenxi Heavy Industry Co Ltd	ABB
Rated power output (kW)	1052	1000
Rated voltage (V)	400	400
Rated speed (Cycle/minute)	1000	1000
Rated frequency (Hz)	50	50
Size (mm)	2600×1900×2082	2496×1460×2032
Weight (kg)	6800	6400
Efficiency	95%	95.8%

Table 2: Comparison of physical performance parameters of typical domestic and overseas ship engines

design, equipment and parts analysis, system testing and commissioning, testing and delivery.

From 2008, SMERI has received orders for the electric propulsion systems of around 20 vessels, including luxury river cruisers, survey vessels, semi-submersible vessels, dredgers, pipe-laying vessels, survey ships, life boats, offshore supply vessels, and far-ocean fishing vessels.

Among them are the World Legend luxury cruise ship for Chongqing New World Cruise Company, an ocean science survey ship for Xiamen University, a 5,000-tonne heavy-lift pipe-laying vessel for an ocean engineering equipment development project led by the National Development and Reform Commission, a large-scale far-ocean trawler processing vessel for the 863 project of China's Ministry of Science and Technology etc.

Leveraging on its experience and knowhow in rail transport CSR has entered the ship equipment market with

electric propulsion system integration services provided by its unit Shanghai CSR HanGe Shipping Engineering which was previously Shanghai Hange Automation Engineering Technology and was bought by CSR in 2011. Shanghai Hange Automation was originally set up in 2000.

CSR has technical advantages in areas such as electrical system, current variation and control, control and diagnosis, large rating electrical components, communication and data applications. The company provides integration services of electric propulsion systems, ancillary equipment systems, whole ship automation systems, and vibration and noise reduction systems.

It also supplies integration solutions for electric propulsion systems including the selection and installation of diesel driven generator sets, distribution boards, transformers, frequency invertors, motors, and propeller; as well as the design,

integration, installation and testing of single propeller bow thrusters.

In May 2014, CSR had installed its first electronic propulsion system on the *XiangYangHong No.10* ocean science survey vessel for the State Oceanic Administration. The company has either delivered or received orders for electric propulsion systems for various ship types including China's first archaeology vessel *ZhongGuoKaoGu No.01*, the country's first jack-up engineering residential vessel, shuttle tankers, and offshore supply vessels.

### Marine diesels

Diesel engines designed and produced by Chinese suppliers are of a relatively high standard after many years of development. The market share of China-made and designed diesel engines is on the rise.

China is able to produce the most advanced low-speed and medium-speed engines with 70% or more of the components made locally. Some of the licensed models were first made in China, such as MAN 6G70ME-C9.2 model, MAN 21/32 model, and Wärtsilä's W-X50DF duel-fuel model.

Table 1 shows the comparison of the physical performance parameters of the first self-developed models of the maritime medium speed engine in China, the "CS21/32" by China Shipbuilding Industry Corporation (CSIC), and an equivalent model, the "H21/32", designed by Hyundai Heavy Industries. The parameters of the two models are similar in terms of power per cylinder and NOx emissions, while "CS21/32" performs better in terms of fuel consumption.

The market share of Chinese brands for medium speed engines remain relatively low. Medium speed engines developed by

ABB Azipod's podded propelling system on an ice-breaking vessel



	Zhuzhou Electric Locomotive Research Institute Co	ABB ACS800-07LC series	Siemens SINAMICS S120 690±10%
Output voltage	690±10%	690±10%	690±10%
Output frequency	48-63Hz	48-63Hz	47-63Hz
Output voltage	0-690V	0-690V	0-690V
Output frequency	0-300Hz	0-300Hz	0-300Hz
Capacity (Power)	1200-2500kW	200-5600kW	75-4500kW
Efficiency	98%	≥98% (accessories not included)	≥98% (accessories not included)
Cooling technique	Water cooling	Water cooling	Air cooling
Control strategy	Direct torque control	Direct torque control	Vector control
Levels of protection	IP21 (standard)	IP42	IP20-IP43
Applications	Marine propulsion, Power Transmission	Marine propulsion, Power Transmission	Marine propulsion, Power Transmission

Table 3: The comparison of performance parameters of typical domestic and overseas marine frequency converters

Chinese companies cover ratings between 1,320kW and 4,400kW. In comparison, Hyundai's HIMSEN contains four series of models, namely: 170mm, 210mm, 250mm, and 320mm cylinder diameters; covering ratings between 575kW and 10,000kW.

Hyundai has also developed various models of dual-fuel engines. Meanwhile, the electrically propelled vessels built in China are mainly installed with medium speed engines provided by Wärtsilä, Caterpillar, and Cummins. Medium speed engines made in China are still rarely seen on China-built vessels.

### Power generators

A number of Chinese companies have launched their own brands of generator, such as Shanxi Fenxi Heavy Industry Co Ltd (Fenxi) and CSSC Marine Power Co

Ltd. The products of these suppliers have reached international standard in terms of modular, systematic and standardised design. Table 2 shows the comparison of the physical performance parameters of a model developed by Fenxi and the equivalent model designed by ABB. The two sets of parameters are rather similar with Fenxi's generator slightly behind in terms of efficiency. However, Fenxi's models are generally heavier and larger in size compared with the equivalent ABB models.

### Frequency inverters

A frequency inverter is a key electronic component in a marine electric propulsion system, which determines the dynamic and static properties of the propulsion unit, as well as the steering of the ship.

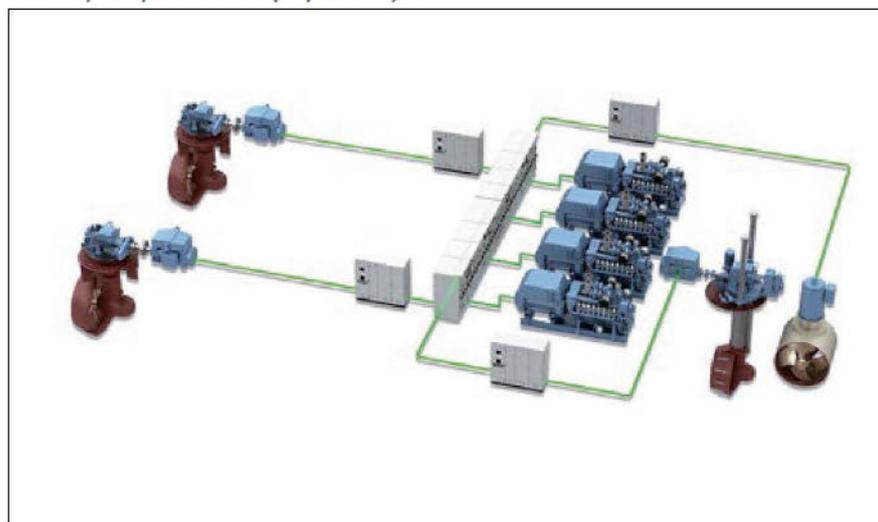
It can also heavily influence the power system and other power and electronic equipment on board and the levels of vibration and noise.

Zhuzhou Electric Locomotive Research Institute Co and CSIC's 712 Research Institute have both launched self-developed products with intellectual property rights. The 712 Research Institute is capable of the design and manufacture of frequency inverters with low voltage 690V and with the capacity below 2MVA, as well as those with medium voltage 3300V and with the capacity below 5MVA. The institute has also commenced the development of high voltage and high capacity frequency converters of 6,000V-10,000V and with capacity 8MVA-16MVA.

Meanwhile, Zhuzhou Electric Locomotive Research Institute Co designed its own models of frequency inverters based on its existing high-speed rail frequency conversion technology. In 2011, the company launched its first 400kW bowthruster frequency inverter which has since been installed on a number of ship types, including shuttle tankers, platform supply vessels and river cruisers.

Table 3 shows the comparison between performance parameters of the frequency inverters from the Zhuzhou Electric Locomotive Research Institute Co and that of similar products from ABB and Siemens. Again, locally-developed frequency inverters have reached international standards in terms of input/output voltage and input/output

Rolls-Royce hybrid electric propulsion system



frequency. However, the production varieties of local Chinese brands are relatively limited and await expansion.

### Propellers

Ships with electric propulsion can be installed with various propeller models, such as fully rotational/all-direction propeller, podded propellers, variable pitch propellers, fixed pitch propellers and hydraulic jet propulsion.

Currently, many domestic companies have launched fully rotational/all-direction propellers under their own brands, such as Wuhan Marine Machinery Plant, the Nanjing High Accurate Drive Equipment Manufacturing Group Co Ltd (NGC Group), SMMC Marine Drive Systems (Suzhou) Co Ltd, Helice-Zhejiang Helicetude Marine Machinery Co Ltd, Wuxi Oriental Changfeng Marine Propulsion.

Local vendors have developed a series of all-direction propeller products including both adjustable and fixed pitch propellers. However, the product varieties in this area are still limited compared with those of international brands such as Rolls-Royce. For instance, domestic Chinese brands still lack an all-direction propeller product with power over 4.5MW and podded propeller product.

Podded propellers installed on Chinese-built electric propulsion ships are mainly installed with Azipod propellers from ABB. Meanwhile, Chinese companies such as Shanghai Zhenhua Heavy Industries Company Ltd and the Wuhan Marine Machinery Plant have commenced R&D on podded propellers.

### Control and Management Systems

The control and management systems of electric propulsion vessels include power management systems, propulsion control systems, and engine room monitoring and alarming systems. Currently, the 712 Institute, the 711 Institute and the Shanghai Ship and Shipping Research Institute have all launched relevant products. The control and management systems developed by Shanghai Ship and Shipping Research Institute have already been installed on some non-electric propulsion ships. Meanwhile, 712's control and management systems have been applied on electric propulsion ships, including research vessels, cruises, bulk carriers, dredgers, and surveying ships.

Smooth operation of a control and management system relies on the seamless integration of all systems onboard. Although domestic control and management systems have reached a relatively high level in certain aspects, they still lag behind their overseas counterparts in terms of compatibility between productions developed by different domestic vendors.

### R&D trends of ship electric propulsion systems

Typical large-scale ships in the market include: large-scale ocean platforms, large-scale pipe-laying crane vessels, multi-task ships, large container ships and luxurious cruises. Their total system capacity usually reaches the level of 50MW, with a usual system voltage of 6.6kV or 11kV for medium to high voltage electric systems. As the size of ships grow bigger, the medium to high voltage electric systems will be more commonly used.

With the advantages of less emission, higher flexibility in terms of control and ease of deployment, direct current (DC) electric propulsion systems have become a focal point for future development. ABB proposed the concept of a marine DC power grid in 2011. In 2013, Norwegian shipyard Kleven delivered the first ship equipped with an ABB DC electric propulsion system, the platform supply ship *Dina Star*. A real ship test showed that ABB's DC electric propulsion system is able to reduce fuel consumption by 20% and deployment space by 30%.

### Multiple energy sources

With the tightening of IMO's emission regulations, power sources for marine electric propulsion systems have diversified. Dual fuel engines and pure-gas engines have gained popularity. In addition, various types of energy sources such as storage batteries, fuel cells, super capacitors and solar power have started to appear onboard.

With the ever increasing complexity in the different systems on a vessel, the amount of data to be processed onboard increases tremendously. The need for information sharing between systems has become more and more urgent.

Meanwhile, integrated bridge systems are already capable of automatically managing the main equipment of an entire ship. In the future, intelligent ships are expected to be able to connect all systems onboard. To cater for this trend, key electric propulsion providers will upgrade their products to achieve the maximum level of automation and intelligence, ease of information sharing and networking, and compatibility with other systems. **NA**

Table 4: Comparison of physical performance parameters of typical domestic and overseas fully rotational/all-direction propeller products

Company	Model	Power range	Maximum diameter of propeller	Model of propeller
Rolls-Royce	US	330kW-5MW	4m	Adjustable/fixed pitch
	UUC	3MW-6.5MW	-	
Wuhan Marine Machinery Plant	WSP	150kW-4MW	3.9m	Adjustable/fixed pitch
NGC Group	NRP	150kW-4.5MW	4.5m	Adjustable/fixed pitch
SMMC Marine Drive Systems (Suzhou)	SRP	45kW-2.2MW	2.65m	Fixed pitch
Helice	MRP	50kW-4.5MW	4.5m	Adjustable/fixed pitch
Wuxi Oriental Changfeng Marine Propulsion Co Ltd	-	44kW-3MW	-	Fixed pitch

# Paradigm lift

LNG cargo tanks have, up until now, been the domain of either Moss or GTT in the larger sizes with more competition seen in the small to medium sized vessel market. That is about to change with the development of Brevik Technology's new cylindrical tank solution, which the company says will offer the industry an easy to build, competitive alternative

Competition in the gas carrying market has been limited, particularly in the larger size carriers with owners complaining of the high cost of containment systems partly due to the complexity of the designs and construction and partly due to the lack of effective rivalry.

Some industry observers believe that Gaztransport & Technigaz (GTT) clings desperately to market share in the membrane containment systems business that have proved popular with owners building the larger vessel sizes, though some owners have complained of the high prices that they are forced to pay for membrane systems, which are built by yards under contract to GTT.

"GTT is very protective of its monopoly," one senior executive told *The*

*Naval Architect*, adding that "this is easy to understand, everyone wants market share". Another executive complained that while the membrane prices were high there was also a cost associated with sloshing damage prevention.

Brevik believes its latest design will change the nature of the gas carrying industry by introducing far greater competition in all sectors of the market for the established companies. Sloshing problems are not expected to affect the Vard design and the company says that the ships will be significantly cheaper.

Very large gas carriers (VLGC) have up until now been built with either membrane cargo tanks, designed by French company GTT, or the mainly aluminium large spherical Moss Tanks. Smaller vessels have a broader range of cargo containment to choose from with prismatic and Type C tanks also in the mix.

In a move that Brevik believes will initiate "fierce" price competition the Fincantieri and Vard subsidiary is announcing the development of its latest design of LNG carrier, which is, quite literally, a bulk carrier with cylindrical tanks for the gas cargo; either LNG, LPG, ethane or ethylene.

Simplicity in the vessel and cargo containment system design has lowered costs and will open the LNG shipbuilding market from a few highly proficient yards to any yard that can build a bulk carrier.

"We have also been helped in the pricing by the reduction in the cost of steel," admitted Vard Technical Manager Andreas Buskop. Vard believes that it can capture a 25% market share of the LNG newbuilding and new tonnage (that is conversions as well as purpose built ships) market by 2020, a bold claim by anyone's standards with its cylindrical LNG containment tank design.

### TECHNICAL PARTICULARS

#### *Deltamarin B.Delta* 32,000m<sup>3</sup> multigas CGC

Length overall .....	175.0
Length between perpendiculars.....	171.7
Breadth, moulded.....	27.0
Depth Upper deck.....	13.0
Design draught moulded.....	6.9
Block coefficient.....	0.87
Service speed .....	14knots

### TECHNICAL PARTICULARS

#### *Brevik 6,500m<sup>3</sup> CGC*

Length overall .....	99.8
Length between perpendiculars.....	97.3
Breadth, moulded.....	18.6
Depth Upper deck.....	15.0
Design draught moulded.....	5.9
Block coefficient.....	0.75
Service speed .....	14knots

The cylindrical tanks on the Vard designed vessel are separate from the hull allowing the tanks to expand and contract



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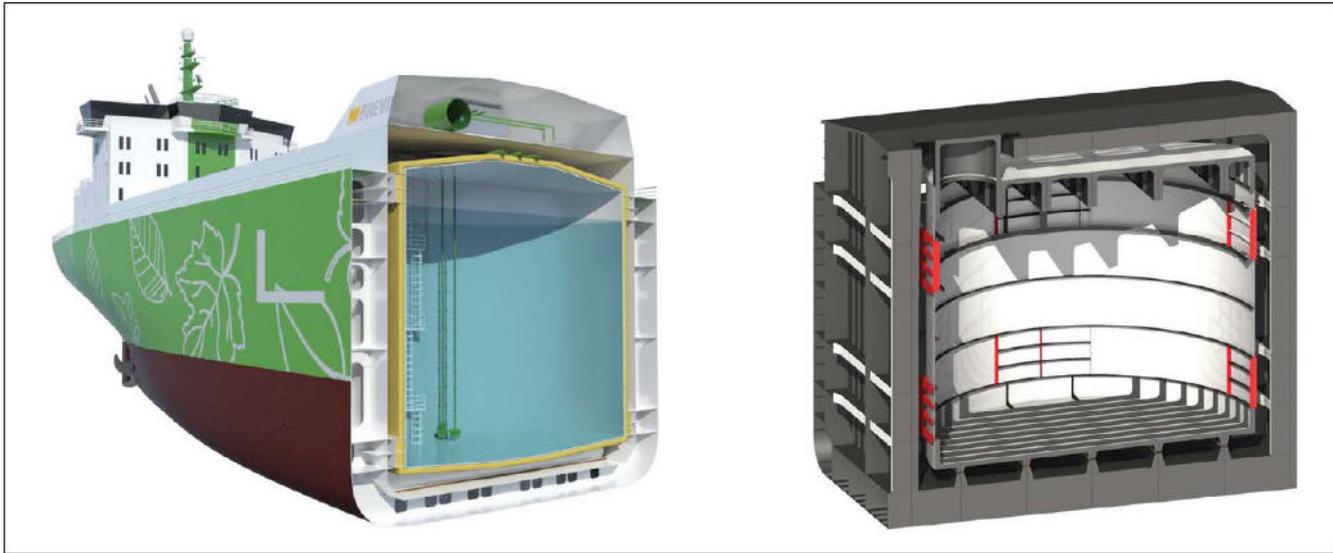
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Cutaways showing the cylindrical cargo tanks in the Vard designed gas carrier

Effectively, Brevik has designed cylindrical steel tanks that can be manufactured in a variety of sizes and built the containment system into Deltamarin's B.Delta bulk carrier design. In order to complete the circle Brevik has entered into a technical agreement with Deltamarin, because the "B.Delta design is perfectly suited to the arrangement of LNG tanks that we provide," explains Arnt Reines, co-owner of Brevik Technology, adding, "The idea is that Deltamarin design the ship and Brevik design the tanks."

The B.Delta ships have an efficient hull that is comparatively simple to build and with the tanks mainly consisting of a steel cylinder

any yard should be capable of delivering the cylinder gas carriers (CGC), lowering costs and offering owners a credible alternative to existing containment systems.

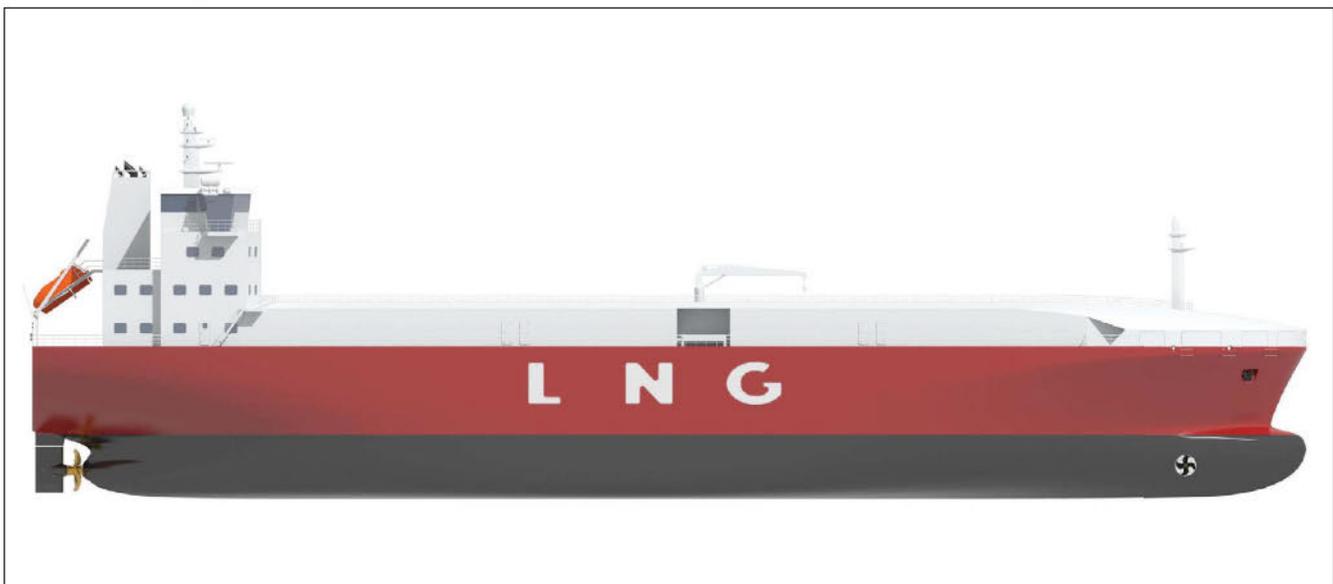
Patrick Janssens, the VP for Global gas Solutions at ABS said that the design of the cylindrical tanks means that they are independent of the hull, "allowing the tanks to expand in all directions without putting stress on the hull"

He added that membrane containment systems require specialist building techniques and a lot of work at the quayside following launch, something the CGC designs will not need. The hull is an established vessel design

while the tank production is separate and will be introduced to the hull at the appropriate point in the shipbuilding process.

According to Buskop the hull side of the technology deal will be handled by Deltamarin and so Vard are uncertain which yard will become the first to sign a deal to build a CGC though he conceded that Deltamarin already has links to a number of yards, particularly in China, which the company has contracted to build a variety of versions of its bulk carriers; these yards include Chengxi Shipyard, Zhejiang Ouhua Shipyard, Yangfan Group Co, the CSC Jinling, Guangzhou Wenchong Shipyard

Profile of the Vard Cylindrical Gas Carrier



and the Tianjin Xingang Shipbuilding, and one of these is most likely to succeed in winning the first CGC contract.

However, Buskop also noted that some of the smaller variations of the CGC could be built by Vard European offshore yards. Buskop adds that Brevik has entered into negotiations with a number of prospective clients and the company is now close to signing the first contracts for the design.

Contract negotiations have been able to reach a more advanced stage for the smaller and medium sized vessels because the detailed pricing necessary for these vessels has now been completed. "We expected a 15-20% price advantage over the membrane designs, but since we have completed the detailed pricing we believe that the CGC design can make savings of between 18 and 25%," claimed Buskop.

Before the end of this year Brevik expects to have a better understanding of the pricing

for the larger vessels and, with the larger ships priced at around US\$200 million each, Brevik believes that the CGC design can achieve up to 25% cost savings for owners here also, although Buskop says the detailed pricing process is not complete, and "savings will be at least 20%".

All the necessary approvals for the design and patents are now coming together as ABS has approved the design in principle while DNV GL took part in the development of the project and has also approved the design.

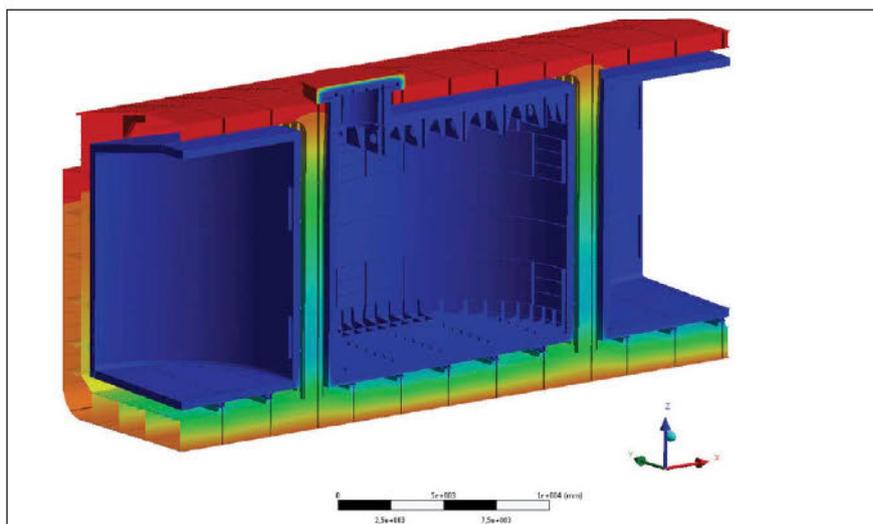
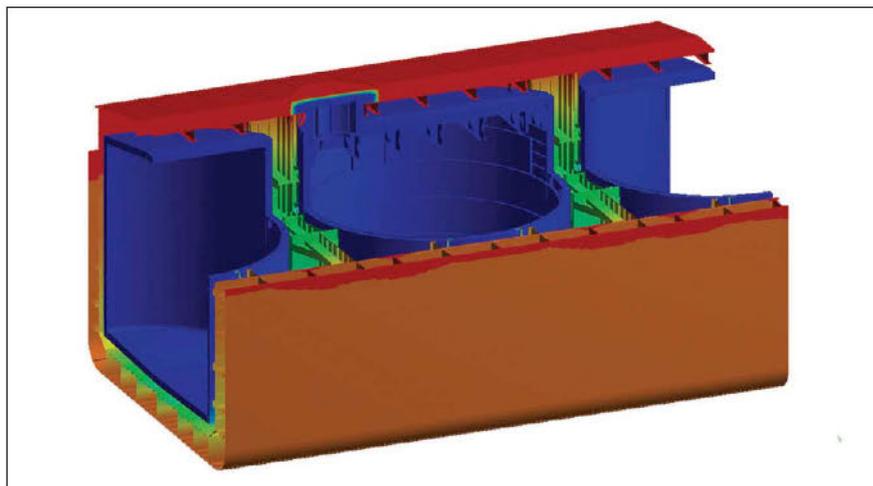
Furthermore, patents have been granted in Norway, Singapore, China and the US, while patents in Brazil, Japan and Korea are now being finalised. European patent rules are being adjusted, but Brevik expects that the patent in Europe will also be accepted once the regulatory process has been concluded.

There are now six variations for the CGC design including the 6,500m<sup>3</sup>, 30,000m<sup>3</sup>,

65,000m<sup>3</sup> and 175,000m<sup>3</sup> LNG carrier designs with a 12,000m<sup>3</sup> and 15,000m<sup>3</sup> LEG and LPG carrier designs.

According to Brevik the company aims to penetrate the small and mid-scale market first moving onto the larger sized vessels at a later stage. The expectation is that the move into the gas tanker market will change that sector significantly with comparatively low cost vessels. And once owners recognise the advantages of the CGC design the orders will come thick and fast, altering the economics of operating gas carriers forever.

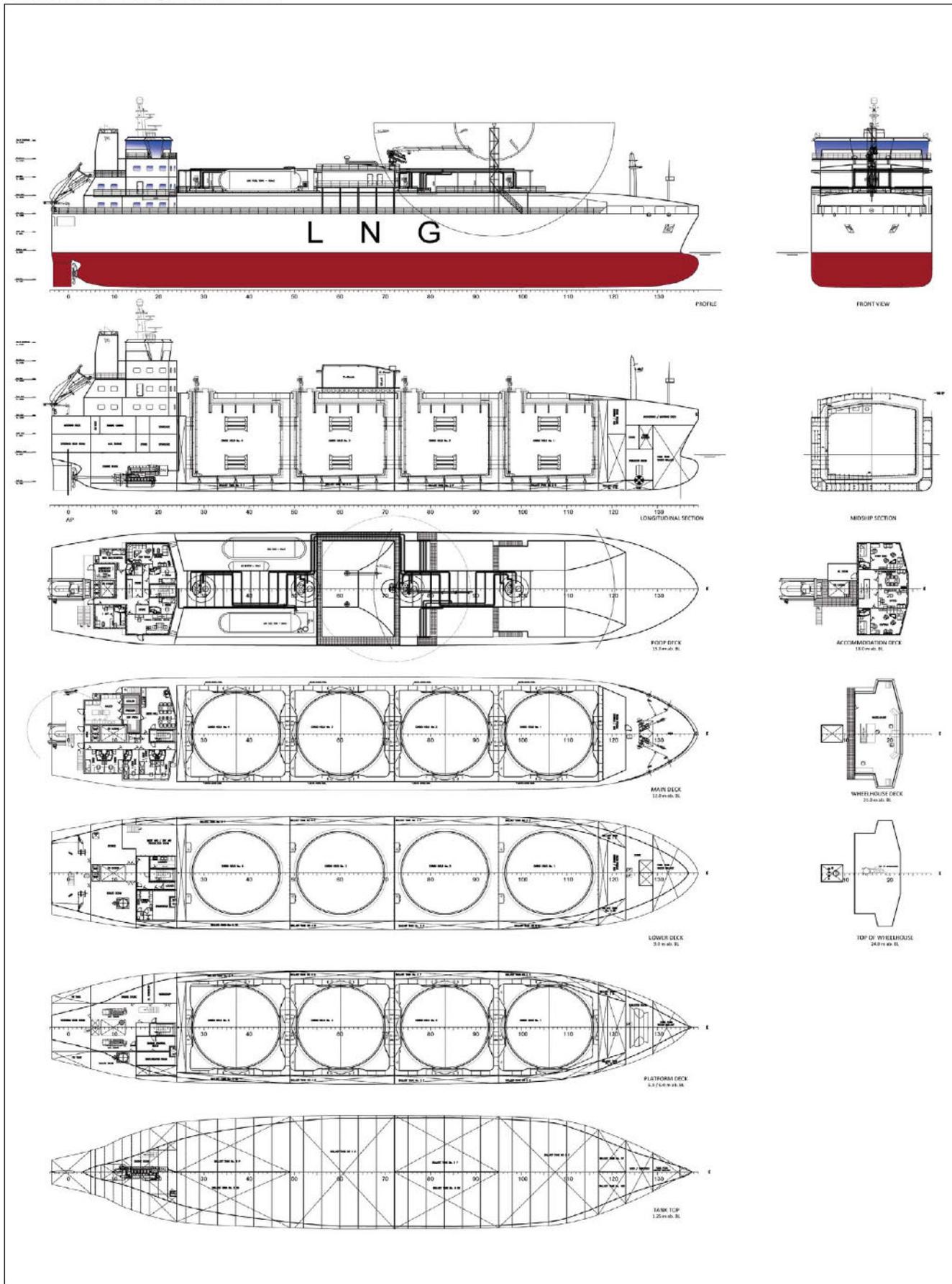
It is a scenario that will lower costs and improve the bottom line for gas operators. Vard expects that once it gains a foothold in the market other companies will be forced to lower prices for gas carrier designs, raising the stakes in the gas carrier market significantly as companies start to battle for market share. *NA*



Finite Element Method analysis of the thermal distribution according to the IGC cold case; other containment system designs require specialist materials to withstand the low temperatures necessary for LNG cargoes



GA for Brevik Technologies' 6,500m<sup>3</sup> CGC



# Trapped in the lion's den

Korean shipping has faced some tough challenges since the watershed moment in 2008. With the collapse of the banking system the global economic anchor was metaphorically applied. Seeking sanctuary in the offshore market shipbuilders have recently found that there was no hiding place. So Korean yards find themselves at yet another turning point

Crisis is perhaps too weak a word to describe the situation currently being experienced by the three major South Korean shipyards, Daewoo Shipbuilding and Marine Engineering (DSME), Hyundai Heavy Industries (HHI) and Samsung Heavy Industries (SHI) which, along with some other large yards, have been bailed out to the tune of US\$42 billion so far.

The Yonhap News Agency reported: "Market leader Hyundai Heavy Industries received the largest amount of 16.4 trillion won (US\$14.08 billion) worth of credit, followed by Daewoo Shipbuilding & Marine Engineering with 15.48 trillion won (US\$13.3 billion) and Samsung Heavy Industries with 10.44 trillion won (US\$8.96 billion)."

Having survived the global economic crisis in 2008 through a shift into the offshore business South Korean shipyards had hoped that they would survive this economic downturn and ride out the storm until calmer waters returned.

Instead, the yards have found that one storm has been followed hot-foot by another with the failure of the commercial shipbuilding market followed by the collapse of the oil price and consequent failure of the offshore marine market. In addition the sector has had to contend with chronic over-capacity in the number of ships currently operating and overcapacity in the shipbuilding market.

This latest challenge may force a more fundamental change to South Korea's shipbuilding industry as yards battle to survive. In the past the battle for survival has mainly been fought by the small to medium sized yards, with the exception of STX. Now, the larger yards are also being dragged into the battle as Daewoo Shipbuilding and Marine Engineering (DSME), once the world's biggest yard,



Samsung Heavy Industries has agreed to help bail out Sungdong despite the Samsung shipbuilder having debts of nearly US\$9 billion itself

has now come under bank control following last year's US\$3 billion loss and Hyundai Heavy Industries has laid off 6,000 staff, according to senior Korean sources.

The Korean Development Bank (KDB) is mulling over whether to sell its, 34% stake in DSME following significant cash injections from the bank. KDB was a state-owned entity until 2009 when it was privatised, but the bank does still operate as a safety valve for much of South Korea's major manufacturing industry, including holding a 40% stake in the ailing shipbuilding giant STX and the Hanjin chaebol which includes the troubled national carrier Korean Air Lines.

Should the decline of new orders for commercial ships continue, allied with the decline in the price of crude oil, which has applied the brakes to the offshore market,

a very different Korean shipbuilding industry may be forced to emerge.

Current expectations are that shipbuilding orders and the price of new ships will not recover to sustainable levels until 2020. Overcapacity in most ship operating sectors and the chronic failure of the global economy to recover its growth trajectory will severely hamper shipbuilders.

Overcapacity in the shipbuilding sector has started to be addressed in China which has seen some 50% of yards either close or merged with similar entities. However, current estimates are that shipbuilding capacity stands at more than 50 million CGT while new orders at the time of writing stand at less than 45 million CGT, suggesting a 10% overcapacity.

These figures remain fluid with overall capacity declining as some yard

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The first batch of Triple E ships being fitted out at DSME in 2014 before the yard ran into troubled times

space is closed down and the dearth of new building orders in both the commercial vessel and offshore sectors are also declining, probably indicating a shipbuilding overcapacity significantly higher than current estimates.

One of the most notable casualties has been Rongsheng in China, but there have been several mergers in Japan and a number of yards in South Korea have faced difficulties, including the 21st Century Shipbuilding Company failing, Sungdong now under the control of Korea Eximbank, and the Shina SB shipyard which is in receivership after having spent five years under bank control. Add to this the once proud tanker builder at SPP, which is now also under the control of several banks, and the picture looks very bleak.

Meanwhile the Korea Eximbank agreed with SHI to cooperate in helping keep the debt-ridden Sungdong yard, which is based in Tongyeong, afloat.

Korea Eximbank is the main creditor of Sungdong with US\$1.7 billion of loans and refund guarantees.

According to local reports SHI will be in charge of Sungdong's sales, procurement, production and technology sectors. Eximbank will manage the yard's human resources, labour issues and financial matters. The agreement will be effective

for four years with an option of three more years.

Crisis management can, however, only serve to delay the downward spiral in the hope that better times will come around the corner. However, only an upturn in vessel orders can help save some of the yards now most at risk. But that eventuality appears to be hopeless. Estimates from Clarksons shipbrokers suggests that just 800 ships will be delivered this year, while other industry observers of the Korean shipbuilding market say that the South Korean shipbuilding industry will be particularly vulnerable to the decline in orders.

Much of the recent pain experienced by the Korean yards has been caused by the collapse of the crude oil price. It is understood that the baseline for crude oil prices, in order for the offshore industry to maintain orders and development, is over US\$80/barrel, with current oil prices hovering at around the US\$45-48/barrel mark. Oil analysts expect prices to have reached just US\$51/barrel by this time next year, offering little hope for a revival any time soon.

One expert told *The Naval Architect*, "If oil prices were to recover to US\$80/barrel there would still be a lag of about a year

before investment in the offshore industry was returned, because investors would wait to see if the oil price was sustainable over the long term."

For Korea the downturn in the offshore market has come at the wrong time as the yards were building a significant niche in the market, with China lagging in technological knowhow. However, Chinese company Wison has won an order for an FLNG vessel to the surprise of some in Korea.

One senior shipbuilding analyst said: "We didn't expect China to win such a complicated order, we are not sure if Wison has the technological knowhow to build such a vessel, they will be dependent on European companies offering the basic design."

The analyst also added that, "China has very rapidly caught Korea up technologically," and this will mean that when the upturn in the offshore business finally does come there will be a significant new clutch of competitors eating away at the Koreans' market share.

Meanwhile, the shipbuilding crises in the shipyards has had a knock-on effect in that the country's marine equipment suppliers are also now in crises as their source of income has been reduced to a trickle.

Sales, according to local equipment manufacturing sources are down by up to 20% in 2015 compared to 2014 levels, and with ship and offshore sales in the major yards reduced by 30%, "we cannot expect any improvement next year," the source bemoaned.

One equipment manufacturing source said that many companies are trying to diversify by looking for markets abroad. This tactic is not having any significant success as most of the other major shipbuilding regions, China, Japan and Europe have their equipment manufacturing industries, that they will support where possible within the local shipbuilding communities.

However, there is some scope to sell to the secondary nations such as Singapore, Malaysia and Indonesia, though these are comparatively small markets.

Overall the market in South Korea is under-going a seismic shift and it is likely that it will emerge from this latest crisis a leaner and more focused industry as a result. **NA**

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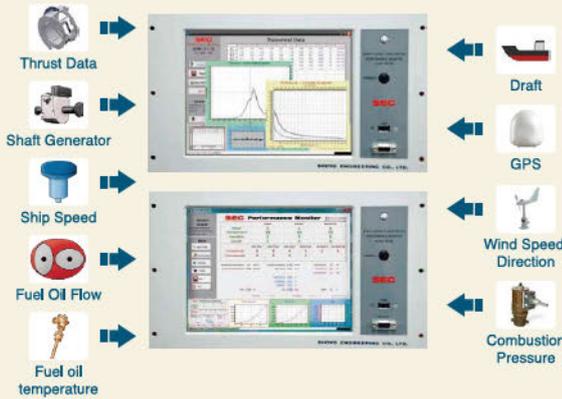
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# Beyond Compliance: the world according to Park

In a frank interview with *The Naval Architect* Korean Register Chairman & CEO BS Park shares his views on the class market, the shipbuilding industry, new ferry regulations and the IMO Secretary-General elect Ki-tack Lim

Shipping remains “in the doldrums”, BS Park announces, as it has been since 2008. He expects the shipbuilding market to recover in 2017 arguing that the yards should be fully booked by then.

However, a simple return to the pre-crisis days remains unlikely as shipyards around the globe and in South Korea in particular struggle with over-capacity of both ships and shipbuilding capacity. In 2008 most Korean yards opted to refocus their businesses on the offshore market in order to weather the loss of commercial vessel business. Today that offshore business has also been hit as oil prices have collapsed, with WTI still at US\$44.63 and Brent Crude at US\$48.14 a barrel at the time of writing. And the prospects of an increase in that level remain remote, with analysts expecting crude oil prices to climb to around US\$51/barrel in a year's time.

However, Park does not believe that the yards will look for another sector to maintain their businesses: “I don't think they [the shipyards] will explore new areas of business as an alternative to offshore. I think they would rather spend this time checking the mistakes of the past and strengthening their technical competence.

“As Korean yards have the capability of servicing a variety of business sectors, it is natural that they will focus on a sector with more demand. I think they are currently nurturing their competitiveness and strengthening their marketing capability by reviewing what they did in the face of keen competition in the past and intensively enhancing their technology.”

Park's view is not merely limited to the narrow economics of the maritime industry, but he puts that into a wider context: “The downturn of the maritime industry is an international phenomenon and Korean shipbuilding is a part of it. If you look at the big picture of shipping and shipbuilding, there is a risk that global transport volume is gradually decreasing compared to the past.



Korean Register Chairman & CEO BS Park believes that the maritime Industry must learn to manage crises better

“The change of economic roles could be one of the reasons. In the past, there was clear segregation between the country of raw material origin and the country of manufacturing. However, currently, we are seeing a trend towards a greater volume of raw materials being processed within the country of origin before being transported to the next location. If this is the case, then a considerable reduction of bulk cargoes will occur, which will inevitably affect the transport volume of vessels.

“There is a concern that the decrease of transport might bring about the decline of the shipping economy and affect the shipping industry in the future.”

As a result of the downturn classification societies have also had to make changes to the way that they operate and, like the shipping lines and shipyards, they too are suffering from the intensification of competition and the consequences of that heightened state of competition. According to Park, KR has adopted a strategy that lays emphasis on strategic partnerships.

“We have developed ‘Beyond Compliance’, a slogan we created at the beginning of the year and sums up our change in strategy. It means that in a difficult and sluggish market, we are creating mutually beneficial partnerships across the industry by offering optimised solutions to our customers which go beyond just obeying the rules.

“The downturn of the Korean shipping industry of course directly affects us as a classification society business. The weakening ability of shipping companies to place orders, fleet restructuring and excessive competition among classification societies are all challenges for KR to face. Our focus is on supporting our customers by providing technical services that improve their ships' operational efficiencies.”

The Beyond Compliance strategy does not stop at partnerships, but has also looked at supporting innovation from equipment manufacturers and others in an effort to boost the industry.

“We are great believers in supporting research and development. We recently

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opened the world's first green-ship equipment test certification centre which is acting as a hub of innovation for this vital area. By offering a certification system for the latest green-ship technologies, we are helping the R&D departments of marine equipment manufacturers commercialise their activities," explained Park.

He added: "We endeavour to diversify our business portfolio by reinforcing non-marine business such as naval services, certification and offshore as well as international marketing to explore more business around the world."

However, the intensification of competition inevitably comes down to price and Park admitted that a battle between class societies is raging as they struggle for market share.

"A battle for the transfer of class is happening and the competition centres around either price or service," he says, adding that, "some class societies are already fighting for fees."

Park says a number of class societies (he declined to name any), were offering five year block fees at reduced rates. He said that KR does not at this time offer five year block fees, "but we may do in the future, if the shipowner is right and the business environment supports it".

Currently KR is concentrating on expanding its portfolio with submarines, warships and coast guard vessels, "we are still too reliant on shipping, which is still 60% of our business," says Park. KR has recently expanded its business into quality assurance, certifying steel plate used for bridge building. And the company is trying to rebuild its reputation following the damaging *Sewol* affair.

In a frank admission Park said that KR had lost around 80 clients for a

number of reasons, mainly bankruptcy. "Daebo International has gone into bank management, Samsun is now under court management as was Pan Ocean which has now been bought by Daelin," he said.

This has led KR to explore overseas markets with one non-Korean owner, Bernhard Schulte, registering 20 ships with the Korean register. "Nobody expected that," laughs Park, adding that "The owners had confidence in the network and the pricing".

The network that Park is referring to is the restructured Korean Register which has cut the number of divisions that it had from 41 to 33 with teams merged and eight team leaders' posts being lost. An emphasis has also been put on training with surveyors being given the necessary tools to do a highly efficient and detailed job.

"Surveyors must be correct [for the job] they must have experience, and we will put the most experienced surveyors into the frontline to protect the client. This is my principle," claims Park.

He is aware of the damage done to the reputation of the Korean maritime sector by the tragic loss of the ferry *Sewol*, an accident in which around 400 people, mainly school children, lost their lives.

Park believes that the ferry departed from Incheon without sufficient ballast to stabilise the vessel and with cargo, both containers and trucks, not properly secured. Lim Ki-tack, the newly elected Secretary-General of the IMO who will take office in January next year, is aware of the difficulties caused by the lack of regulation in the local shipping market.

According to Park, Lim and the IMO want to extend IMO regulations that currently

only cover international shipping. These international rules should be applied to locally operated "ferries and fishing boats too", such as *Sewol*; currently these vessels are subject to government regulation.

KR is also looking to further improve safety by increasing the number of surveyors sent out to jobs. "Usually only one surveyor completes a survey on a vessel, but I have ordered that two surveyors will now go to each survey job to improve surveying efficiency," explained Park.

Increasing the number of surveyors sent to a job at a time of deep industry crisis will either prove to be financial suicide or a clever move to differentiate KR from its competitors. Either way, Park believes that the industry must learn to manage crises better.

"The international shipping and shipbuilding markets are suffering and I expect this sluggish market will continue for the time being. The ongoing economic crisis seems to have become a part of our daily lives and has become an everyday challenge for us all. Crisis is something that we have to manage.

"We have to be precisely aware of the situation and manage the crisis and the risk by efficiently making use of resources such as technology, capital, data and manpower. I believe that we will meet these challenges through good management. I see KR as a comprehensive technical advisor which is constantly managing its and its customers' risk in the most efficient way in an ever-changing industry. We need to be prepared for the regular cycle of downturn and upturn of shipping and shipbuilding."

These aims are definitely Beyond Compliance. *NA*

## Owners seek to mitigate BWTC costs

Shipowners are looking to limit the cost of fitting Ballast Water Treatment Systems through a regulatory loophole. The rules as they stand could see many ships delaying the fitting of treatment systems by five years or in some cases they may never have to fit them at all

Owners have railed against the introduction of the Ballast Water Treatment Convention (BWTC) and their protests have successfully delayed the regulation for more than 10 years.

Some of the complaints raised by owners and their lobby groups have been justified as the BWTC was developed before the technology was in place that would allow the proper enforcement of the regulation.

Owners were also concerned with the high cost of installing Ballast Water Treatment Systems (BWTS), with some systems initially costing in excess of US\$2 million to buy and install per ship plus the

energy costs for operating the system. And unlike other green technology there was no payback for owners, merely costs and an avoidance of fines and other sanctions for failing to meet regulations.

However, current regulations require owners to fit BWTS in the first survey for the vessel after the BWTC enters into force. Mike Lee the sales & Marketing Director at Techcross in Busan, South Korea, told *The Naval Architect* that some owners were bringing forward the date of their ships' survey so that the vessels will have up to another five years without having to fit a ballast cleaning system.

"Owners can then wait until the ship is ready for scrapping or for the prices of BWTS to come down significantly," explained Lee.

All newbuilds will be required to be fitted with a BWTS at the time of construction.

Ballast water treatment systems manufacturers, including Techcross and

NK have reported that sensor failures are a problem for their systems, with sensors needing to be replaced every two to three years. Both companies buy the sensors used in their systems from an outside source and Jae-chul Jung, assistant manager of sales at NK in Busan, says "We are having to replace sensors after two to three years, but they are getting more reliable."

Both companies also identified crew training as a crucial element to the safe, efficient and effective operation of BWTS. Lee said Techcross had established training centres in Korea and Mumbai, India, which offer training sessions free of charge because the crew "need to be educated" in trouble-shooting and maintenance.

Lee said that the training programme had been established following two explosions caused by both "human error and a design fault". Both explosions had been caused by the crew believing that

the BWTS had shut down, but in fact the system was still running. "This caused a build-up of pressure and finally an explosion," explained Lee, adding that the initial solution was to fit a pressure relief valve, but now they have new systems in place that will prevent the build up of pressure altogether.

Overall Techcross has signed contracts for 869 units since 2009 up to 1 July this year with 598 units delivered to the yards, 190 contracts were signed in 2014 and 220 in 2015. NK says it has had 404 orders in total up to 2014 with 105 systems installed and 59 ships have been delivered.

Both NK and Techcross said that between 25-50% of ships fitted with BWTS are actually operating them and that this gives the manufacturers some operational feedback that was previously unavailable. Neither manufacturer reported any major problems from the systems in operation. *NA*

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# Testing a vessel's mettle

Successful residual strength analysis during an emergency response depends on using simplified approaches to ensure that rapid and accurate guidance is provided to interested parties. The limitations of these simplified approaches should be understood and validated by more advanced methods, write Martin Petricic and Eric VanDerHorn, ABS

Despite preventative efforts, ships experience accidental damage from collisions, groundings and explosions which may pose a risk to the safety of the ship's personnel, the vessel itself and the surrounding environment.

Additionally, recent high-profile marine incidents have shown the pressure that is placed on ship-owners in the aftermath of a casualty. This has highlighted the need to better understand the residual strength of the structure, not only during the initial stabilisation of the vessel at the incident site, but also in managing the transit of the damaged vessel safely to a port or repair facility.

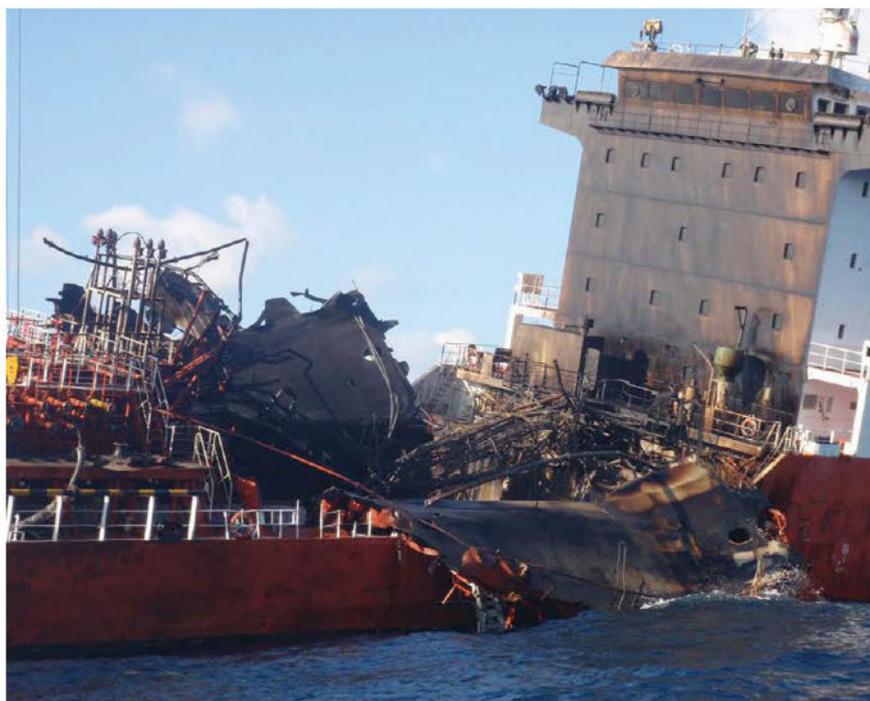
## Hull girder ultimate strength

When considering an increasing longitudinal bending moment, the structural members of a hull cross-section will begin to fail due to buckling or yielding. The maximum capacity of the cross-section before complete global collapse is known as the hull girder ultimate strength (HGUS).

HGUS assessment is one of the most fundamental analyses for determining the global strength of the vessel in both intact and damaged conditions.

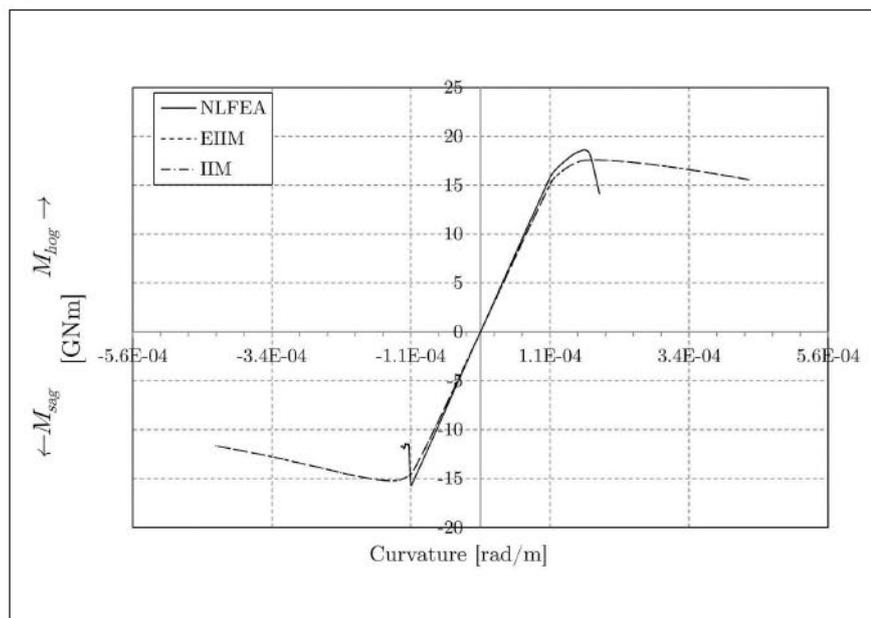
Many studies have examined the residual HGUS of damaged vessels and various approaches have been proposed; from simplified formulae to full nonlinear finite element analysis (NLFEA).

The approach most widely implemented for the evaluation of the residual HGUS is the Smith method, also known as the incremental-iterative method (IIM). This methodology is employed during the design stage in the International Association



Accuracy in assessing residual strength following an accident can be crucial

Figure 1: Moment-curvature curves for intact tanker



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		Incremental-Iterative Method		Enhanced Incremental-Iterative Method		Comparison (IIM vs EIIM)	
Ship Type	Damage	Hogging [GNm]	Sagging [GNm]	Hogging [GNm]	Sagging [GNm]	% Diff (H)	% Diff (S)
	Intact	9.443	-8.176	9.444	-8.180	-0.01%	-0.05%
FPSO	Collision	8.700	-6.962	8.239	-6.733	5.30%	3.28%
	Grounding	6.565	-6.594	6.379	-6.285	2.84%	4.68%
	Intact	17.564	-15.224	17.566	-15.232	-0.02%	-0.05%
Tanker	Collision	15.156	-12.145	13.902	-11.481	8.27%	5.46%
	Grounding	13.516	-13.586	13.372	-13.268	1.06%	2.34%
	Intact	16.368	-14.482	16.378	-14.492	-0.06%	-0.06%
Bulk Carrier	Collision	14.874	-12.167	13.572	-11.518	8.76%	5.33%
	Grounding	12.003	-13.590	11.946	-12.916	0.48%	4.96%

Table 1 Comparison of IIM and EIIM results IIM HGUS results for applied VBM

of Classification Societies' (IACS) Common Structural Rules (CSR).

### The incremental-iterative method

The IIM is based on the assumption that the vessel's prismatic hull girder behaves like a beam. Navier's hypothesis states that for a beam subjected to bending, plane sections will remain plane as the curvature or moment is continuously increased. Based on this hypothesis, the IIM assumes that the hull girder failure will be due to stiffened panel failure between two transverse frames, also called inter-frame collapse. This assumption of the inter-frame collapse failure mode has been validated for intact vessels through comparisons with NLFEA results.

In the IIM, a representative transverse section of the hull girder is divided into small longitudinal structural elements. Each element is assumed to act independently as the entire hull structure is loaded and the resulting behaviour of each structural element to this applied load is determined using pre-calculated elastic-plastic stress-strain curves (or end-shortening curves).

The neutral axis of the transverse section is located at the equilibrium position determined by the balancing of the tensile and compressive axial forces. To apply a bending moment on the section, the applied curvature is increased in a process called curvature control, during

which, incremental vertical and horizontal curvatures are applied to the section with a prescribed ratio,  $\phi_H/\phi_V$ .

As the curvature is increased, the structural response of the longitudinal elements will result in the neutral axis shifting to maintain equilibrium. After each increment in curvature, the corresponding resultant moment carried by all of the structural elements can be calculated. This represents the bending moment-curvature relationship. The ultimate strength of the hull girder is defined as the peak value of the bending moment-curvature relationship.

The traditional IIM, given as the requirement in CSR, is based on the curvature control method, where the horizontal curvature is constrained,  $\phi_H=0$ . This is equivalent to restraining the neutral axis of the section to be parallel to the baseline. Thus, at each curvature increment, the corresponding applied vertical and horizontal bending moments represent the applied moments necessary for constraining the neutral axis to be parallel to the baseline.

During the design stage, the intact cross section considered is typically symmetrical about the centreline. When applying the IIM curvature control method to this symmetric section, it is apparent that the horizontal bending moment necessary to constrain the horizontal curvature is always zero. This conveniently allows the traditional IIM ultimate bending

moment results to be evaluated by directly comparing them with the design vertical bending moment.

When the cross section is asymmetric, the applied horizontal bending moment required to keep the neutral axis parallel to the baseline will no longer be zero. As the curvature is increased, the corresponding applied vertical and horizontal bending moments will change nonlinearly to maintain the prescribed curvature ratio. Thus, when the peak value of the bending moment-curvature ratio is reached, the corresponding applied bending moment represents a combination of both vertical and horizontal bending. This makes it impossible to evaluate the resulting ultimate strength value with any specific applied bending moment value.

### The enhanced IIM

To overcome the limitations of the traditional IIM method in handling asymmetrical sections or combined loading cases, an Enhanced IIM (EIIM) can be considered. The EIIM uses an alternative means of incremental load control called the moment control method. For the moment control approach, instead of controlling the curvature ratio, the vertical and horizontal bending moments ratio applied to the section is prescribed,  $M_H/M_V$ .

This approach ensures that the hull girder ultimate moment can be compared with any applied biaxial bending moment.



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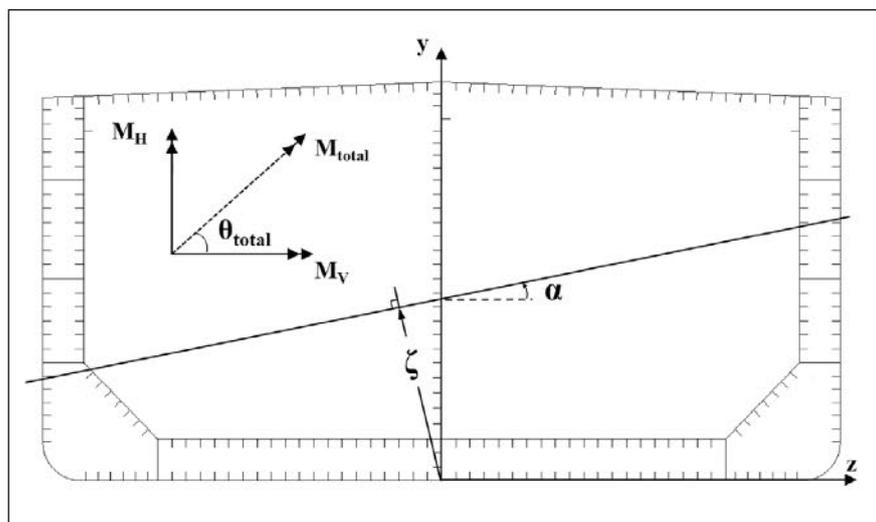


Figure 2: Applied moment angle and neutral axis angle

Prior to running the analysis, a bending moment ratio is prescribed corresponding to the biaxial loading condition that is to be considered. For each incremental step, the curvature is increased and the neutral axis must be translated and rotated to ensure that the equilibrium conditions are met and the prescribed bending moment ratio is maintained.

To determine the rotation and translation of the neutral axis at each incremental curvature, the EIIM uses two convergence criteria which ensure that both force and moment equilibria are met. An iterative loop is used to simultaneously determine the position and rotation of the neutral axis taking into account any given structural asymmetry and applied biaxial bending moment ratio.

### Comparison of the IIM and EIIM

The EIIM results were compared to the results obtained using the traditional IIM for several different sample ship types subject to collision and grounding damage extents as detailed in the Hull Girder Residual Strength chapter of the CSR. To simulate the damage, any element that falls within the damaged region is removed from the cross-section. The first observation that can be made is that the results for the intact case are nearly identical. This is the expected result, since the cross-section is symmetric and only a vertical bending moment is applied.

This represents the unique case where the curvature control method and moment control method are equivalent.

While the intact results are shown to be similar, it can also be seen that for all the considered damage cases, the EIIM provides a more conservative estimate of the HGUS than the traditional IIM.

This effect becomes more noticeable as the degree of asymmetry is increased. The largest differences are seen between the IIM and EIIM for cases with the greatest amount of structural asymmetry

This result can be explained by the difference in the principles of curvature control versus moment control. If the transition between the intact structure and the damaged structure is considered, it can be noted that the neutral axis position cannot be discontinuous at the point where the damage begins. Rather, it will shift continuously until an equilibrium point is met near the centre of the longitudinal extent of the damage. This is due to the restraining effect of the surrounding intact structure.

If the longitudinal extent of damage were to be made infinitesimally small, the stiffness of the surrounding intact structure would fully restrain the neutral axis of the damaged section. This is the condition that is being considered in the case of the traditional IIM with curvature control. As the asymmetry in the structure becomes more pronounced, these stiff boundary conditions provide the required horizontal bending moment restraint necessary to maintain zero horizontal curvature.

This consequently results in a larger HGUS value when compared to the EIIM where the neutral axis plane orientation is assumed to be unrestrained by the

surrounding intact structure and fully developed within the damage region.

### Validation using NLFEA

Nonlinear finite element analysis (NLFEA) is considered to be the most advanced method for ultimate strength calculations of intact and damaged hull structures. It enables a refined computation of the progressive collapse behaviour, it accounts for the interaction between the local and global failure modes, and it considers all types of structural nonlinearities.

Therefore, NLFEA provides a good baseline for validating the key assumptions of simplified approaches, such as the IIM and EIIM.

In an ongoing NLFEA study at ABS involving more than two hundred damaged cases and four different vessels, the key IIM assumption of the interframe collapse failure mode has been confirmed in all intact cases and the majority of damaged cases, even for heavily damaged structures.

Several cases were identified where pure interframe collapse was not the observed failure mode, and as such, these cases show the largest deviations between the different HGUS approaches. In those cases, the damage to the transverse and longitudinal structure is such that it leaves a large unsupported portion of the deck or inner bottom between the transverse bulkheads leading to overall deck or inner bottom buckling.

It is important to note, however, that these cases occur due to the complete removal of the specified damaged structure from the model. This assumption of damage is potentially conservative since actual incidents will likely result in buckled and yielded structure in the damage region that could continue to provide some level of structural support. Further study is required to determine if the non-interframe collapse failure modes continue to occur when these complexities in the damage definition are included in the model.

Additionally, unlike the IIM and EIIM, the NLFEA is a 3D approach, so the longitudinal extent of the damage

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The safety of the seafarer and protection of the maritime environment begins with good design, followed by sound construction and efficient operation. Naval architects and engineers involved in the design, construction and operation of maritime vessels and structures can make a significant contribution to safety and the Royal Institution of Naval Architects, with the support of Lloyd's Register, wishes to recognise the 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 annually to an individual, company or organisation that in the opinion of the Institution and Lloyd's Register, is judged to have made an outstanding contribution to the improvement of maritime safety or the protection of the maritime environment. Such contribution may have been made by a specific activity or over a period of time. Individuals may not nominate themselves. Nominations are now invited for the 2015 Maritime Safety Award.

Nominations of up to **750 words** should describe the nominee's contribution to:

- safety of life or protection of the marine environment, through novel or improved design, construction or operational procedures of ships or maritime structures
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**The closing date for nominations is 31 December 2015. The Award will be announced at the Institution's 2016 Annual Dinner.**

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must also be considered. It has also been confirmed in the ABS NLFEA study that the longitudinal damage extent has a very small effect on the ultimate bending moment capacity. On the other hand, the effect of discontinuities and stress concentrations at the damage ends has a significant negative impact on the onset of progressive collapse of the hull girder.

### Comparing IIM, EIIM, and NLFEA

It can be concluded that the agreement between all three methods in the intact condition is quite good. This is consistent with the results from past studies. It was also found that compared to the NLFEA, the EIIM presented an improvement over the regular IIM in all the intact and damaged cases. The improvement is largest for collision damage cases where the amount of structural asymmetry is more pronounced.

Despite the improvement offered by EIIM over IIM for all cases, the difference between the NLFEA and EIIM results was still large for several of the damage cases. The largest difference between the NLFEA and the EIIM in analysed damaged scenarios is 13.59%.

It was postulated that the potential reason for this discrepancy is the existence of sharp damage corners and structural discontinuities in the longitudinal direction for the NLFEA model. To test this theory, the longitudinal damage extent was changed from three web frames (3 WF) to extend along the entire length of the FEA model (ALL WF), effectively removing the discontinuities in the longitudinal direction. After re-running the NLFEA model with this change, the results come into an excellent agreement with the EIIM (-2.33% difference). This similar effect was also observed for the other damage cases.

This demonstrates the sensitivity of NLFEA to the existence of structural discontinuities and stress concentration areas that can lead to earlier development of failure mechanisms and different overall collapse sequences. This also points out one potential difficulty in modelling the real-world damage scenarios using NLFEA in emergency situations where knowledge of the true damage extent may be difficult to obtain.

Ship Type	Comparison (IIM vs NLFEA)		Comparison (EIIM vs NLFEA)	
	% Diff (H)	% Diff (S)	% Diff (H)	% Diff (S)
FPSO	-6.62%	-2.61%	-6.61%	-2.56%
Tanker	-6.15%	-3.03%	-6.14%	-2.98%
Bulk Carrier	-6.69%	-7.66%	-6.63%	-7.59%

Table 2 Comparison of HGUS results for the intact condition

Ship Type	Comparison (IIM vs NLFEA)		Comparison (EIIM vs NLFEA)	
	% Diff (S) (3WF)	% Diff (ALL WF)	% Diff (S) (3WF)	% Diff (ALL WF)
FPSO	12.92%		9.97%	
Tanker	18.31%	3.26%	13.59%	-2.33%
Bulk Carrier	14.92%	8.22%	9.46%	3.05%

Table 3 Comparison of HGUS results for the collision condition

Ship Type	Comparison (IIM vs NLFEA)		Comparison (EIIM vs NLFEA)	
	% Diff (S) (3WF)	% Diff (ALL WF)	% Diff (S) (3WF)	% Diff (ALL WF)
FPSO	13.37%		10.84%	
Tanker	6.02%		5.01%	
Bulk Carrier	12.85%	9.37%	12.43%	8.93%

Table 4 Comparison of HGUS results for the grounding condition

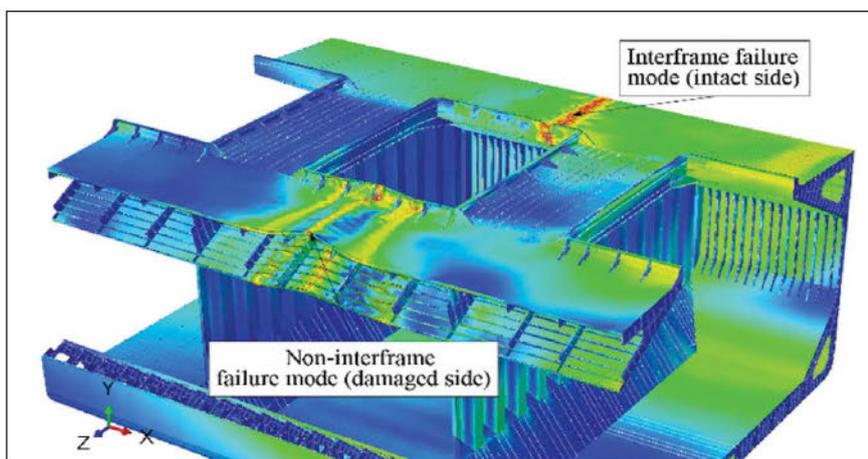
However, removal of the structural discontinuities did not address the differences in the results for all of the damage cases. As was previously stated, several cases exhibited non-interframe collapse failure modes. For the bulk carrier with grounding damage in hogging, the effect of the non-interframe buckling mode, after the longitudinal damage discontinuity effect is removed, remains at

8.93%. This result is consistent with the fact that overall inner bottom buckling is the primary failure mode and this deviation from the IIM assumptions leads to the difference in results.

### Conclusions

The results for the traditional IIM were compared with the results from the EIIM

Figure 3: Failure modes on damaged and intact side of a bulk carrier with collision damage in pure sagging



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for both the intact and damage conditions. Next, to validate the EIIM approach for residual strength calculations, an extensive comparison with the NLFEA results was performed. The following was concluded:

- Agreement in the results for all three methods is quite good for the intact condition;
- The EIIM method yielded results that are consistently more conservative and closer to the NLFEA results, when compared to the IIM method, especially in damaged cases with a high degree of asymmetry. The interframe collapse assumption has been confirmed by the NLFEA for all intact cases and most of the damaged cases;
- In all the damaged cases with the default longitudinal damage extent, the NLFEA yielded more conservative results compared to the EIIM;
- The effect of structural discontinuities at the longitudinal damage ends of the NLFEA model has a significant negative impact on the onset of failure mechanisms and the progression of hull girder collapse;
- If the effects of longitudinal structural discontinuities are removed, the agreement between EIIM and NLFEA becomes very good.

The results from this study support the use of an incremental-iterative approach to evaluate the residual hull girder strength of a damaged vessel during an emergency response. The NLFEA analysis confirmed that the primary assumptions of the IIM, such as interframe collapse, still mostly hold true in the damage condition.

Additionally, NLFEA has shown that the EIIM provides an improvement over the traditional IIM when considering asymmetrically-damaged cross sections. Finally, while NLFEA provides the most conservative results, the time and complexity in performing this type of analysis does not support its application in emergency response situations. *NA*

## Authors:

**Martin Petricic** currently holds the position of Engineer at ABS. He is involved in structural strength, vibration, reliability, and fatigue analysis of ship structures. His work mainly focuses on nonlinear and dynamic analysis using the finite element method. He holds a PhD and MS in ocean engineering from the University of California at Berkeley and a BS in Naval Architecture from the University of Zagreb, Croatia.

**Eric VanDerHorn** currently holds the position of Engineer at ABS. He is responsible for developing software tools to support the Rapid Response Damage Assessment department with the structural analysis of damaged vessels. Prior to joining ABS, he worked as a strength engineer at Boeing performing structural analysis for damaged aircraft structures. He holds a MS and BS in mechanical engineering from Washington University in St. Louis.



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# Modern materials fight fires better

Replacement gas for the now banned halon, which proved lethal, is making fire-fighting onboard ship less of a hazard, writes Sandra Speares

Firefighting training is just one of the courses that takes place at Wilhelmsen Ships Service's facility in Antwerp under the aegis of Roger Gundermann, technical manager Safety Service.

Ships are equipped with both portable firefighting systems and breathing apparatus, but also fixed firefighting systems which could amount to many hundreds of cylinders, commonly using CO<sub>2</sub>.

WSS's sister company Wilhelmsen Technical Solutions supplies shipyards and newbuildings with fixed systems. Once the ship enters into service it moves to WSS for supplies of chemicals or firefighting services. While the use of halon for fighting engine room fires was banned several years ago, there are alternative gases available which are man-made and more user-friendly than CO<sub>2</sub> which is lethal for anyone in an enclosed space if used when a fire breaks out.

In the case of chemical gas, "you should vacate the space before you put the gas in there, but if an accident did happen and somebody was in the space it is not life threatening. Chemical gases and inter gases are much less life threatening."

WSS does not produce those gases itself but big suppliers include Dupont and ICI. A mixture of training and experience is very important he says, not least because people will react differently in a stressful situation. Regional managers will assess whether those trained are competent.

Small fires can be tackled with portable fire extinguishers, but engine rooms contain a lot of flammable material and high pressures can mean the fire can spread very rapidly. The firefighting systems are highly regulated and are not automatic in order to ensure the system does not go off when people are still in the room. CO<sub>2</sub> cylinders must be stored outside. Release cabinets for the CO<sub>2</sub> are operated in a sequence with a key in one cabinet used to open the next one.

"There are a lot of steps to be taken in order to operate the system". While training drills onboard may be monthly or every two weeks for firefighting and breathing apparatus, drills for the more complex equipment are rarer



Roger Gundermann says new fire fighting systems are safer than the earlier CO<sub>2</sub> systems

and much depends on how good the operator is. "There are some very well organised ships and some less organised ships," he says.

When each release cabinet is opened there is a time delay with flashing lights and alarms to warn the crew to vacate the premises and a further time delay before the gas is actually pumped into the enclosed space. WSS is responsible for removing the cylinders from ships when they are empty or need servicing and does this in its own service centres.

Foam systems are also used for fire protection in the engine room. With high expansion foam, which mixes foam liquid with water. One litre of liquid will provide 600 litres of foam bubbles, he explains. One of the new generation gases is a product from 3M called Novec 1230. Gundermann explains that it has good fire extinguishing properties and the gas has a very low evaporation rate. Like halon it is possible to remain in the engine

room without danger, but it is much more eco-friendly than halon he says.

3M Novec 1230 Fire Protection Fluid is an advanced, "next generation" clean agent halon replacement designed to balance industry concerns for performance, human safety and the environment, according to the manufacturers. "This makes Novec 1230 fluid the first option to non-sustainable technologies suitable for use in a wide range of offshore and land-based operations/applications to protect occupied spaces, critical equipment & most of all people."

Gundermann says that CO<sub>2</sub> system regulations require it to be discharged within two minutes. With Novec the discharge is 10 seconds.

WSS also produces a wide range of chemicals through its Unitor brand including cleaning products to protect seafarers from infections. All the products are produced in Norway. [NA](#)

# RINA-QinetiQ

## Maritime Innovation Award

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

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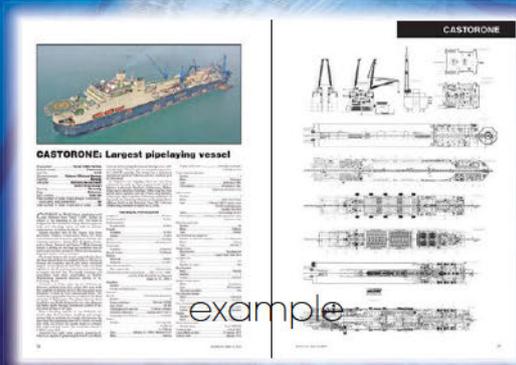
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# Redesigns and future needs

Developments in the collection, storage and analysis of data can make the future efficacy of bulbous bows and other retrofit designs a little more certain, according to DNV GL

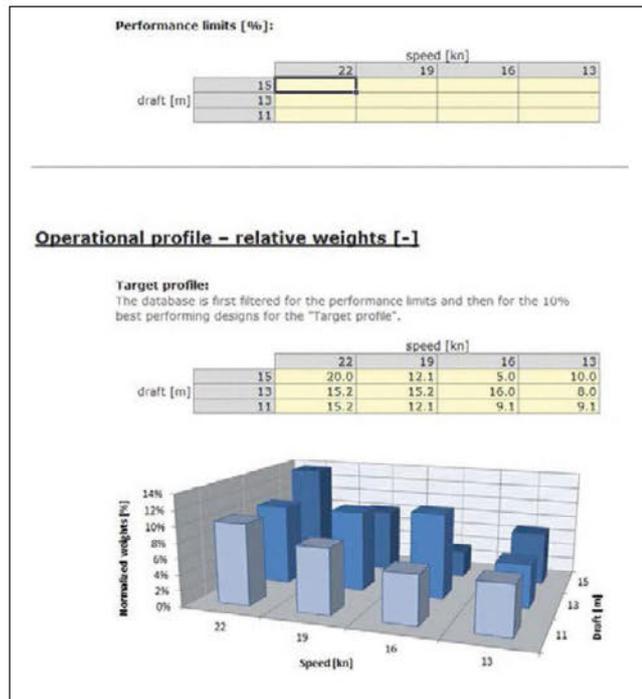
German and Norwegian classification society, DNV GL, is developing a data tool that will help to define the operational and alternative operational profiles of vessels undergoing efficiency retrofits. The new tool will act as a preliminary study that “may serve as a guideline to setup the future operational profile of the vessel class under consideration for ECO Retrofit Bow,” says DNV GL.

The tool, ECO Explorer, reflects a shift towards the study of off-design conditions, and is set to work in partnership with Automatic Identification System (AIS) data and noon reports, producing a database of design information that will allow technicians and customers alike to instantaneously calculate the results of different efficiency measures in terms of their predicted savings. This will provide a more detailed picture of the effect and cost of changes to operating conditions, future-proofing design work, according to DNV GL.

A typical retrofit bow project is divided into four phases: lines digitalisation; a cost-benefit analysis of the potential effects a retrofit project might have; the carrying out of the retrofit investigation if it has been deemed viable; and model tests, which act to authenticate the findings of the computerised investigation.

However, this design process fails to consider the selection of the operational profile, the profile on which retrofit projects are based. Loosely defined, the operational profile is the level of efficiency best suited to the physical and commercial conditions the ship operates within, which makes the value of the retrofitting project dependent on the operational profile chosen. For example, if the operational profile was not necessarily what the client intended, the costly retrofit calculation would have little impact, damaging the ROI.

In the past, says DNV GL, retrofit service providers expected to receive operational



An example of ‘weights’ used in the parameter study of operational profiles and the seeking of a vessel’s target profile

profiles from their clients, but these were inherently difficult for clients to pinpoint because of a lack of comparative data for ship performance. Indeed, the necessary tools to carry out a thorough examination of differing operational profiles did not exist.

Clients were left with numerous questions as a result of this ‘best guess’ scenario: have I identified the correct saving potential of my vessel; could I have chosen a ‘better’ profile; what would happen if we came to operate at other conditions in the future? All of which indicated that design specificity without the facility for inter-vessel or inter-design comparison was problematic, hindering decision-makers and increasing the risk of poorly conceived bow retrofit projects.

In addition, market volatility, especially the cost of oil, continues to force operators and service providers to more deeply scrutinise how ships are functioning, can function and should be functioning in the future. Perhaps more starkly than in any other industry, fuel costs are literally

shaping operations; bulbous bow redesigns and new retrofits reflect an operator’s need to optimise their vessel for fast or slow-steaming conditions depending on the price of oil.

The ECO Explorer database tool, which is still in the development stage, mitigates these issues in a unique way, according to DNV GL. It works from an underlying database of 5,000 bow designs (created and analysed in advance), AIS data, technical vessel information and vessel performance data, which can be used for comparing operational profiles. As more clients use the service, entering their own specification needs into the system, the pool of stored data increases, allowing for a progressively more detailed insight into hypothetical performance and savings.

Crucially, the new tool helps clients in two ways. Firstly, by replacing narrow studies based on a contracted maximum speed with parameter studies that seek out a broader range of operational conditions, and

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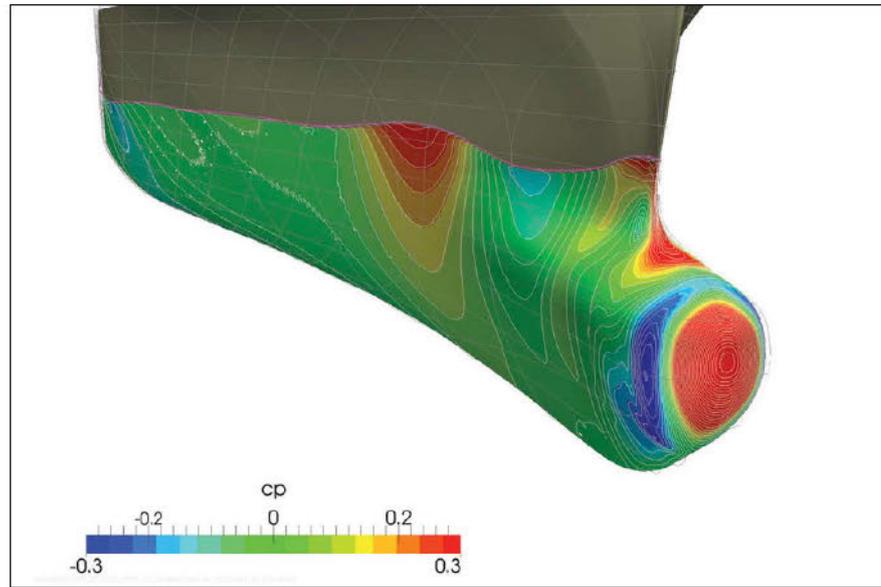
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secondly, by immediately calculating their return on investment (ROI) as individual variables are changed.

Parameter studies are an important response to market volatility as they incorporate the effects of market changes. ECO Explorer facilitates this wider study, working from design weightings (usually related to the fuel oil consumption and estimated time the vessel is sailing in each condition) which can be applied to fit customer briefs on an individual basis. These act to assure ship owners and operators of their commercial future, guaranteeing a wider range of conditions in which their redesigned vessels can cost-effectively operate, according to DNV GL.

AIS data provides the range of operational cases for the particular vessel class under consideration or for similar vessels belonging to competitors. DNV GL says, ECO Explorer can use this data to show whether it makes sense to impose constraints like a desired minimum performance at a specific point (e.g. catch up speed), or if lower or higher draughts can be included in the profile. In addition, hydrodynamic properties, such as delivered power, are computed for each single variant as well as each operational condition in the database, further specifying the study.

However, for any practical operator, ROI is the bottom line. To meet this need, the interactive Excel tool can assess fuel cost savings based on how operational



CFD-based performance prediction is used in ECO Explorer's calculation of annual operational savings

profiles are defined, extrapolating CFD-based performance prediction to represent annual operational savings (US dollars) in real-time. This "real-time" calculation is an important feature, as "Should customers want to change any elements of the analysis the tool simply recalibrates the new input to create more what-if scenarios and to ensure that the final design is future-proof," says DNV GL. This makes it much easier for customers to choose the right design profile for their present and potential future needs. The tool uses an integrated fuel consumption calculator to translate

vessel power reduction to US dollars per annum, and takes aspects such as fleet size, conversion costs and fuel price into account to estimate the return on investment.

While the future is inherently uncertain, and future-proofing may always be too strong a description, DNV GL appears to have expanded its sphere of analysis to answer a great deal more 'what if' scenarios for its customers. Operators with tightly held purse strings are sure to be pleased with the added security DNV GL's database and ECO Explorer tool offers long-term investment in bow retrofit designs. *NA*

Part of the ECO Explorer interface comparing the return on investment of different operational profiles

**Return on investment in fleet**

€/USD:  [-]

Steel price:  [USD/kg]

Fleet size:  [-]

Interest rate:

Years of operation:  [a]

<ul style="list-style-type: none"> <li>- Optimization (incl. potential) flat 101,266 USD</li> <li>- Model testing flat 107,278 USD</li> <li>- Steelwork for new bulbous bow per vessel 504,648 USD</li> </ul> <hr/> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Total (fleet)</td> <td style="text-align: right;">6,768,964 USD</td> </tr> <tr> <td>Total (per vessel)</td> <td style="text-align: right;">520,690 USD</td> </tr> </table>	Total (fleet)	6,768,964 USD	Total (per vessel)	520,690 USD	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Target profile</th> <th style="text-align: center;">Alternative profile</th> </tr> <tr> <th style="text-align: center;">Return on investment in fleet</th> <th style="text-align: center;">18 months</th> <th style="text-align: center;">20 months</th> </tr> </thead> <tbody> <tr> <td>Accumulated savings after 10 years</td> <td style="text-align: right;">3,606,332 USD</td> <td style="text-align: right;">3,206,354 USD</td> </tr> <tr> <td>Net present value when considering 10 years</td> <td style="text-align: right;">2,013,757 USD</td> <td style="text-align: right;">1,790,411 USD</td> </tr> </tbody> </table>		Target profile	Alternative profile	Return on investment in fleet	18 months	20 months	Accumulated savings after 10 years	3,606,332 USD	3,206,354 USD	Net present value when considering 10 years	2,013,757 USD	1,790,411 USD
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# RDSO by coupling CAESES and NavCad

HydroComp, Inc. and Friendship Systems AG have successfully completed an optimised submersible AUV hull form design by utilising the companies' principal software tools as a coupled solution for Rapid Design Space Optimisation (RDSO). Donald MacPherson, HydroComp and Stefan Harries, Friendship Systems report

**G**eometric hull form modelling and optimisation was performed by Friendship Systems CAESES with hydrodynamic analysis conducted in HydroComp NavCad (Premium Edition). This study employed a new scripting module in NavCad so that it can be run as a very efficient "coupled solver" simulation library.

The original intent of the design study was to develop an AUV hull form optimised for minimum shaft power using an open-source CFD package. However, it was determined that the time needed with CFD to investigate the scope of variants to be considered (i.e. the design space) greatly exceeded the allotted time and resources. In response to this, the coupled RDSO pairing of CAESES and NavCad was employed as a preparatory stage to narrow the scope of the design space and also to establish quantitative benchmarks for the CFD analysis. Simply, HydroComp's NavCad software was utilised for the automated prediction of resistance and propulsion for each of the CAESES optimising design variants.

To insure that overall cost- and time-effectiveness of a design solution is as high as possible, it is necessary to make use of Rapid Design Space Optimisation. The CAESES-NavCad RDSO solution insures that the potent CFD resources are focused on localized optimization and validation of results.

## Overview of computational approach

The paired software tools were given clearly defined responsibilities – CAESES for geometry creation and optimisation, and NavCad Premium for hydrodynamic hull form and propulsor analysis. The connection was via flat text file transfer of data and instructions to NavCad from CAESES and performance results to CAESES from NavCad.

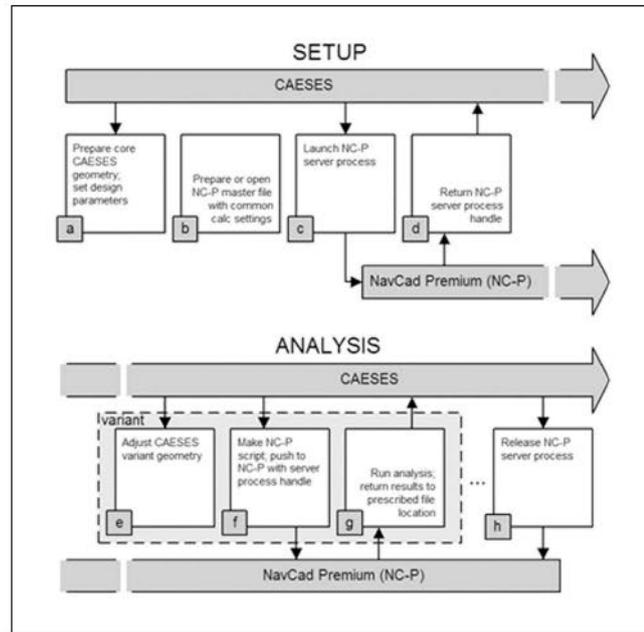


Fig. 1: Processes and file transfer between CAESES and NavCad Premium

CAESES is the "design manager" of the coupled pair, with NavCad generating the simulation performance results. Both programs are launched and run simultaneously, using a NavCad-based "run script" data transfer utility as needed. The general approach is illustrated in Figure 1.

The steps to setup and run an optimising RDSO calculation between CAESES and NavCad are:

- a. Create a parent of the hull form and determine the defining geometric parameters that will be allowed to vary, and appropriately prepare the geometry in CAESES. Establish the CAESES optimisation techniques (as described further below).
- b. Define the prediction settings to apply in NavCad (e.g. resistance prediction method and options) and create a master file. (Note: Although the entire command set can be passed to NavCad using scripting calls, it is often more

convenient to set up a master NavCad project file with all analysis settings, and then limit the data transfer to just the variables that can be changed.)

- c. Launch NavCad in quiet "server mode" and establish data communication parameters using command line arguments. A unique NavCad server process "handle" ID insures the fidelity and security of the coupled calculation space. This handle ID is returned to CAESES to use with calls to this particular instance of NavCad.
- d. Adjust the hull form in CAESES (per the defined optimisation technique).
- e. CAESES prepares a NavCad Premium script for the given variant adjustment. The script includes instructions to open the pre-defined "master settings" project file, pass data for the adjusted CAESES geometry, run calculations, and return results.
- f. NavCad completes the calculation and CAESES will poll for the return of results

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via a transfer file notice mechanism (such as file time stamp). It then applies the NavCad results for use by the optimisation algorithm. Repeat steps d-f for each variant. g. Upon completion of the optimisation study, CAESES passes a script call that closes the NavCad Premium server process.

CAESES and NavCad are run simultaneously, and each is launched under compliance of its own end-user licensing. During the time that CAESES manages the RDSO study, a dedicated instance of NavCad must also be running and “connected” so that calculation authority remains with CAESES. Once a NavCad process is launched for CAESES, it will exclusively serve it until NavCad is closed and the program license is released. This dedicated instance of NavCad insures that calculations are completed and returned properly without interruption from other clients, disruption of calculation timing, misdirection of results, or premature unloading of NavCad.

### AUV performance simulation

HydroComp recently developed a parametric prediction module for submarine and SWATH performance prediction for NavCad. The definition of “body-of-revolution” submersible geometry is suitable for the AUV study and uses three longitudinal regions – a forward ellipsoid-like nose, cylindrical mid-body, and an aft ogive-like tail, Figure 2. (The strut is only needed for SWATH and is ignored for the AUV.)

The standard ITTC-1978 Performance Prediction Method is used for the prediction of resistance and hull-propulsor interaction. NavCad’s existing function library was called on for added appendage resistance as well as propeller sizing and propulsion analysis.

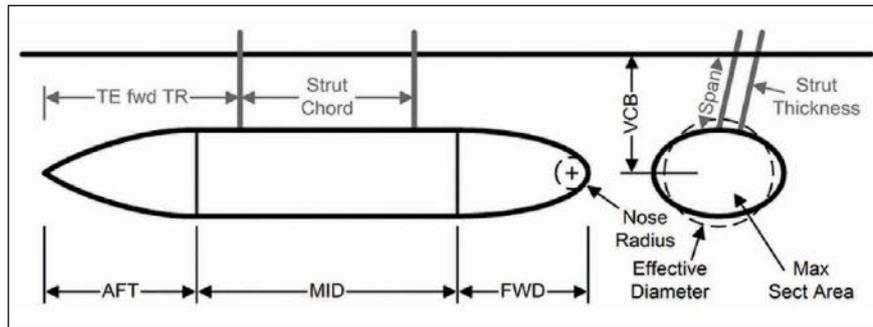


Fig. 2: AUV geometry definition

### CAESES geometry management

As a Computer Aided Engineering (CAE) system for optimising design studies, CAESES calls on third-party analysis (simulation) codes, utilising their outputs to drive the design evolution. CAESES manages geometry (and its variations), pre-processing, connection to the third-party codes, post-processed ranking of variants, and general design assessment.

Several modelling strategies are available to define and vary CAD geometry – the user can set up fully-parametric models from scratch (which was employed for the AUV project) or existing geometry can be imported with only the pertinent changes described parametrically. The search for optimum principle dimensions is nearly always best served with a fully-parametric model, as they enable investigation of broad changes in early design and fine-tuning at later stages.

For the purposes of relatively simple AUV geometry, just a handful of discrete hull form parameters (e.g. length, displacement, wetted surface, etc.) adequately describe the model – all of which are built from forward (nose) and aft (tail) shape equations using only body diameter, forward length, and aft length as variables. All other hull form parameters are dependent on these three variables.

### Scripting for batch calculation

NavCad Premium includes two features that allow it to run as a coupled solver, including a batch or macro scripting API for data and processes, and quiet mode operation without the GUI (i.e. “server” mode).

HydroComp’s scripting API was inspired by other scripting languages (such as VBScript), and was developed to be simple, logical, and object-oriented. (Scripting is also being added to the HydroComp PropElement detail propeller code.) A simple example script for surface shipbatch calculations is shown below:

```
App.Clear
App.OpenFile "C:\Temp\MyProject.hcnc"
' set description
Project.Description "New data available"
' add new hull data for the transom stern
Hull.BeamWLAtr 9.14 m
Hull.ImmersionDraftAtTr 2.05 m
' refine speeds
SpeedPerformance.Count 10
SpeedPerformance.Speed 6 8 10 12 14 16
18 19 20 22 kt
' point to 19 kts as the design speed
SpeedPerformance.DesignSpeedIndex 7
' change the rudder type
Appendage.RudderType BalancedPlate
' change the resistance prediction method
Resistance.HullDragMethod FuncCRTS
' run prediction
App.BuildResistancePrediction
' push pertinent results to output file
App.StartOutput "C:\Temp\NewOutput.txt"
SpeedPerformance.
    AddToOutput Count
SpeedPerformance.
    AddToOutput Speed
SpeedPerformance.
    AddToOutput DragTotal
App.EndOutput
CAESES launches NavCad in quiet
```

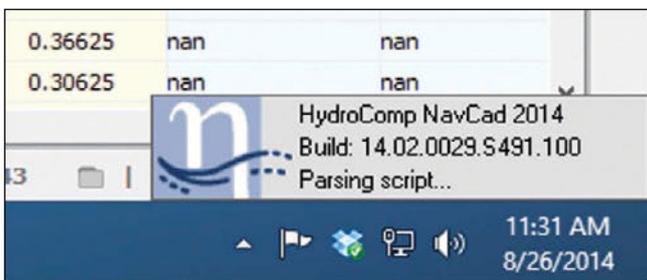


Fig. 3: NavCad “quiet server mode” notification

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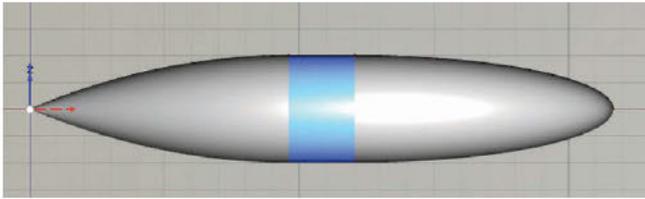


Fig. 4: Successful candidate: 2.17 m L, 0.40 m D, 22.0 N Resistance, 45.6 kW Power

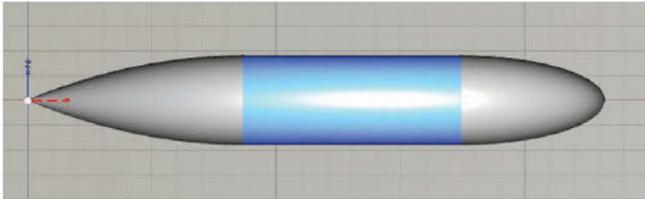


Fig. 5: Successful candidate: 2.32 m L, 0.36 m D, 24.6 N Resistance, 51.4 kW Power



Fig. 6: Unsuccessful candidate: 3.70 m L, 0.28 m D, 47.4 N Resistance, 108.3 kW Power

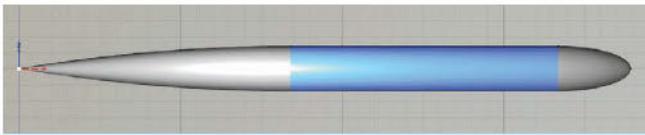


Fig. 7: Unsuccessful candidate: 3.79 m L, 0.28 m D, 61.7 N Resistance, 148.5 kW Power

server mode, and it runs as a background application. (See the notification popup in Figure 3.) The process is simple, computationally very efficient, and mitigates typical cross-platform hurdles. NavCad can be shelled in server mode from any platform that can read and write to a Windows computer, including from a Linux computer on a common network.

### Optimising the design

The objective function for the AUV study was to minimise shaft power for a given displacement volume. Each iteration included prediction of resistance followed by sizing of a thrust-matched two-bladed fixed pitch propeller. Propeller matching was conducted using NavCad's internal propeller optimisation routine, rather than optimisation within CAESES.

Several CAESES optimising strategies (i.e. "design engines") were tested. "Sobol sequencing" is a popular technique to explore a design space by placing the next variant in the region that is currently least "populated". As a quasi-random search, its pattern may look random, but it is actually deterministic. The Sobol

objective is to gather information about the design task with as little computational cost as possible. Unlike a matrix-like exhaustive search, a Sobol sequence will not necessarily increase the number of evaluated variants in proportion to the number of free variables.

Once a constrained design space has been established, an "exhaustive search" then interrogates the design space. The defined geometric parameters are systematically varied in a multi-dimensional matrix, evaluated, and documented. Of course, a design space could easily reach many thousands of potential variants, so an exhaustive search is typically only appropriate when using highly efficient solvers and very few free variables.

The best results came from mapping out the design space with Sobol followed by an "exhaustive search" within a reduced domain and with adapted bounds for the free variables. Since the NavCad calculations are very efficient (taking less than 5 seconds for resistance, propeller sizing, and propulsion analysis on an office-grade Windows computer), a large Sobol analysis of more than two-thousand

designs was run over the course of a few hours. The results allowed the geometry to be refined, with the range of the design variables tightened to exclude results with higher shaft power. An exhaustive search with four subdivisions on three variables was run on this new geometry, which ultimately produced the final design.

The set of just three variables was deliberately selected for this exploratory study. Of course, commercial studies would likely include additional constraints such as for payload geometries (a minimum mid-body length, for example) or LCB position (for vehicle manoeuvring). Greater complexity is easily accommodated by the coupled CAESES-NavCad RDSO solution.

### Analysis and selection of designs

As mentioned, three variables (diameter, forward length, aft length) were evaluated in a systematic series, so four values spanning each variable range make up a final series of 64 variants. Using an ordinary business-grade computer (3.3 GHz Intel-i5; 8 GB RAM; 64-bit Windows 7), total computational time of only 5m:41s was required for the series analysis (i.e. 5.3 s per variant).

The search offered the following example results. (Images are in correct relative scale.)

### Conclusions

The CAESES-NavCad study confirmed that a shorter length with larger diameter best served the objective of minimum shaft power (as realised via lower drag and larger available propeller diameter). For the particular design speed, this is consistent with expectations. Of course, the outcome may be very different with a different design speed or different design constraints.

RDSO is achieved via coupling of CAESES and NavCad, due both to the use of NavCad Premium as a very efficient solver and the linked modelling and optimisation capabilities of CAESES. The very broad and comprehensive prediction models in NavCad with the adaptive geometric modelling and optimising capabilities of CAESES make this a valuable pairing for the RDSO of any marine vehicle. *NA*

# A positive trend

Luxembourg-based dredger specialist, Jan De Nul Group, has invested in a variety of new vessels this year in response to positive market trends and demands in the dredger sector

**T**hree new-builds have been commissioned by Jan De Nul of Luxembourg, including the world's largest cutter suction dredger and two smaller multipurpose vessels. The company has continued to pursue development and growth despite the challenging economic climate affecting many in the marine industry.

## JDN8069 – 'the greatest'

The record-breaking 151m cutter-suction dredger, referred to as *JDN8069*, is set to improve Jan De Nul's operational capability, extending its reach and range of activities.

A spokesperson for the company says: "With this new vessel we will be able to dredge harder rock, to discharge the dredged soil over larger distances, to work in more extreme wave conditions... Thus significantly enlarging the range of works we can perform."

The vessel will be powered by MAN Diesel & Turbo, who will provide one MAN 14V48/CR engine with an output of 16,800kW and two MAN 9L48/60CR engines with individual outputs of 10,800kW. Its total diesel installed power is over 40MW, substantially greater than the current largest cutter-suction dredger, *J.F.J De Nul* – also owned by Jan De Nul Group. RENK, part of the MAN Group,

will provide gearboxes for the vessels' diesel-electric plant, cutter-head drive, dredger, and booster pumps.

Vice president and head of four-stroke marine at MAN Diesel & Turbo, Lex Nijsen, says: "This new vessel represents a significant development within the dredger segment in that, up to now, the largest installed power on similar vessels was approximately 27-28MW, a figure the new vessel easily surpasses."

Each engine is equipped with TCA-type exhaust-gas turbochargers, electronic fuel-injection systems, and hardware and software for engine control, monitoring and diagnosis.

*JDN8069* features a flexible spudcarrier with adaptive control of longitudinal movement and force, the roll angle and moment, and the pitch angle and moment. It also offers a flexible suspension of the cutterladder, which absorbs the shock and vibration incurred during rock dredging.

The vessel will be built at the Uljanik Brodogradiliste shipyard, Pula, Croatia, and is scheduled for completion in February 2017.

## A sister solution

Two new multipurpose vessels, *JDN8625* & *JDN8619*, will also be added to Jan De Nul's expanding modern fleet. These sister vessels will be diesel-electric powered and offer cable-laying and rock installation modes, freeing up other vessels which have previously been converted for these purposes.

A spokesperson for Jan De Nul says: "In addition to the large SRI [Subsea Rock Installation] vessels in the fleet, JDN uses two converted splitbarges for smaller rock installation works, or in case a smaller vessel is needed to safely access the area. The new vessels will perform this kind of work in a more efficient and economical way. This will also enable us to return the converted vessels to their original function, i.e. splitbarges operating together with barge-loading cutter dredgers or backhoes."

Operators will be able to install rocks at depths of roughly 600m while using the vessels in rock installation mode, utilising a flexible and inclined fall pipe that will enable accurate rock installation around a variety of structures, including offshore foundations and oil & gas platforms, according to the company.

The vessels can also support subsea trenchers on the burial of cable, and can be fitted with a cable carousel and other related equipment. DP2 systems enable the cable laying and rock installation modes, maintaining the vessels' position during operations.

The sister vessels will be built at AVIC Weihai shipyard in Weihai, China, and are scheduled for completion in 2017. The vessels comply with the IMO Code for Special Purpose Ships.

## Continuing the trend

When asked about the future for Jan De Nul, a spokesperson said that the company will always endeavour to provide clients with the best and most economical solution for their project, maintaining a forward-facing and technologically inclusive philosophy.

"Jan De Nul Group is constantly investing in its equipment and in new technologies. There are always new designs of vessels on the shelf. It is a permanent process. Of course, not all designs made are ordered at a shipyard, but we are always looking for new opportunities, new technologies, new designs." **NA**

### TECHNICAL PARTICULARS

#### JDN8069

Length, oa.....	151.3 m
Breadth.....	36.0 m
Draught.....	5.75 m
Dredging depth.....	45.0 m
Suction pipe diameter.....	1,100 mm
Discharge pipe diameter.....	1,100 mm
/1,000 mm	
Barge loading pipe diameter.....	1,000 mm
Submerged pump power.....	8,500 kW
Inboard pump power.....	2 x 3,000 kW
Cutter power.....	8,500 kW
Propulsion power.....	2 x 3,000 kW
Total installed diesel power.....	40,975 kW
Speed.....	12.0 knots

### TECHNICAL PARTICULARS

#### JDN8625 & JDN8619

Deadweight.....	6,400 tonnes
Length, oa.....	96 m
Breadth.....	22 m
Draught loaded.....	6.5 m
Dynamic positioning.....	DP 2
Propulsion power.....	2 x 1,250 kW
Bow thruster power.....	2 x 1,250 kW
Total installed diesel power.....	6,800 kW
Speed.....	11.5 knots

# A new era - the arrival of the motorship

Just before the First World War and in the same year that *Titanic* was lost the pioneering motorship *Selandia* entered service. Richard White takes a look at the discussions surrounding the vessel generally accepted as the herald for modern age shipping

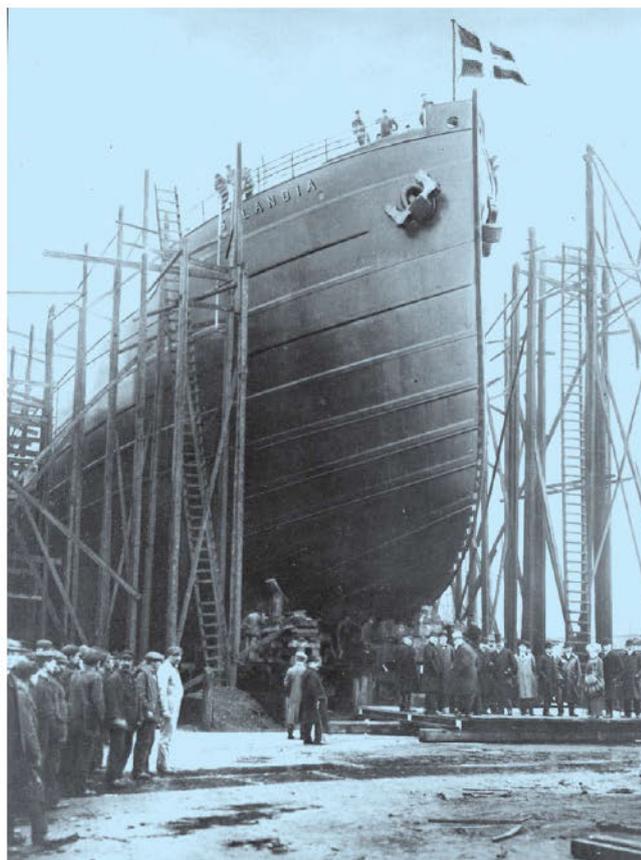
**M**uch has been written, justifiably, about the pioneering motorship *Selandia* of 1912, both when the ship was new and on the centenary. It was far from the first diesel powered ship but its success and its economical operation convinced many shipowners that the diesel was the marine powerplant of the future.

An example of the intense interest attending *Selandia* and its sisterships was a paper by Ivar Knudsen of Burmeister & Wain (B&W) in Copenhagen read by J T Milton at the INA Spring Meetings in 1912. Titled "Results of trials of the diesel engine seagoing vessel *Selandia*" it covered sea trials and the first part of the maiden voyage to London, with a follow up that the ship had reached the Red Sea on its voyage to Bangkok and was running well.

In December 1910 the East Asiatic Company of Copenhagen placed orders with B&W for two vessels, *Selandia* and *Fionia*. They were to be 113m long, 16m beam, 9m deep and 7,000dwt on a 7m draught to suit the harbour approach depths and cargo volumes of the company's Far East trade.

Layout was two hatches forward, then superstructure with bridge and well-appointed passenger accommodation, a hold aft of this, then the engine room above which were the officers' quarters, an aft fourth hatch and crew accommodation in the poop. In an age of big funnels and status in having several of them, the EAC motorships were conspicuous in not having funnels at all, the exhaust being led up the aft mast, driving home the message that here was something different.

Knudsen's INA paper concentrated on the main engines and auxiliary machinery. B&W had become an early Diesel licensee and had developed engines of various sizes for land and marine power. *Selandia* was given two 8-cylinder engines of 21in bore, a size that was at the time considered to be the largest that would avoid piston cooling problems, of the four stroke type direct coupled to twin screws turning at nominally 140rpm.



*Selandia* was delivered in 1912 and was a pioneering design at the time

Each engine was rated at 1,250 indicated hp. *Selandia's* engines were totally enclosed and force lubricated. A direct coupled engine has to be reversible, one of the major challenges to the designer especially with 4-stroke engines because of the need to alter valve timing to suit the direction of rotation.

B&W had developed an effective way by lifting the cam followers and then moving the camshaft along to bring into play a second set of cams. Direct air starting used air at 20bar produced by compressors driven from the auxiliary engines, which also drove the dynamos to supply the ship's extensive electrical system, including pumps, all the winches and the electrohydraulic steering gear. Some of the air was further compressed to 60bar by compressors on the main

engines for the air-blast fuel injection system. A small oil fired boiler provided steam for cabin heating, the evaporators for making fresh water, and for cargo hold firefighting.

*Selandia's* trip to West India Dock in London was not on the itinerary of a normal EAC voyage, but was designed to present the ship to naval as well as commercial marine visitors. The INA meeting was well attended, with some notable people taking part in the extensive discussions at the meeting which ranged widely. Some speakers disliked the closed crankcase engines, wanting open frames like the reciprocating steam engines that marine engineers were familiar with, others wanted pumps and compressors built on to main diesel engines, not driven by auxiliary engines; criticisms that drew

the response from Knudsen that in constant stopping and starting, main engine driven compressors would not keep up with demand, and that closed crankcases with doors allowed both full pressure lube oil circulation and ease of inspection. Some queried the wisdom of using sea water for main engine cooling, while others wanted to promote bigger and more powerful engines of various configurations they were planning or building.

The most interesting part of the discussion was, however, about oil as marine fuel. The tone was set by Sir Marcus Samuel (of Shell) whose company was supplying EAC with oil fuel from wells in Borneo. "We have guaranteed them supplies for five years at an extremely low price." He reminded the audience that diesel ships were not entirely novel, and that the pioneering tanker *Vulcanus*, a much smaller vessel, had been giving good service for a year.

The rate of diesel ship evolution was amazingly quick, and he said "It is because I feel absolutely convinced beyond any doubt that these engines are going to take the place of steam that I speak as forcibly as I do upon the subject. The question of oil supply is undoubtedly a grave one, but if you will accept it from me, I say without hesitation that we have no fear whatever of the oil not being forthcoming. In our own fields in far away Borneo our production today is something over two and a half million tons of oil, but could be enormously increased if we had the offtake. At present we have not only nothing like the number of wells flowing which we might have, but we have been obliged to shut them down."

Fuel consumption of diesel engines, and comparison with coal fired steam was covered in some detail. In his paper Knudsen had given consumption for *Selandia* as 165 grammes per indicated horsepower per hour for all purposes. This was queried. Knudsen clarified the matter. This figure could be broken down into 145g for the main engines and the rest to all the auxiliary engines, but the IHP being that of the main engines. Both engines for *Selandia* had been run on the Copenhagen testbeds driving a dynamo. The service rating of each engine was 1,250 IHP, a conservative figure as 1,500 had been demonstrated. At 1,250IHP the mechanical efficiency was 85%. If we recalculate into today's normal units we get a specific consumption of 229g/bkWh for main engine alone, or 260g/bkWh for all purposes referred to main engine output.



*Selandia* en route to Asia

*Selandia* carried enough oil in double bottom and wing tanks for 30,000 nautical miles at service speed. Knudsen noted that the fuel had a paraffin content and stiffened, becoming unpumpable at low temperature. To ensure reliable operation in winter in Danish waters wing tanks were fitted with heating coils.

There was interest in comparing the work got out of a tonne of fuel in a motorship like *Selandia* with a coal fired steamship of the same size and power. This was difficult as oil carried in double bottoms did not affect cargo space, whereas bunkers needed for a long range on coal did. But there was broad agreement that 2 tonnes of oil would do the work of 3 tonnes of coal in a boiler, and that for a tonne of oil used by a diesel engine ship, a coal fired steamer would consume more than 4 tonnes of fuel.

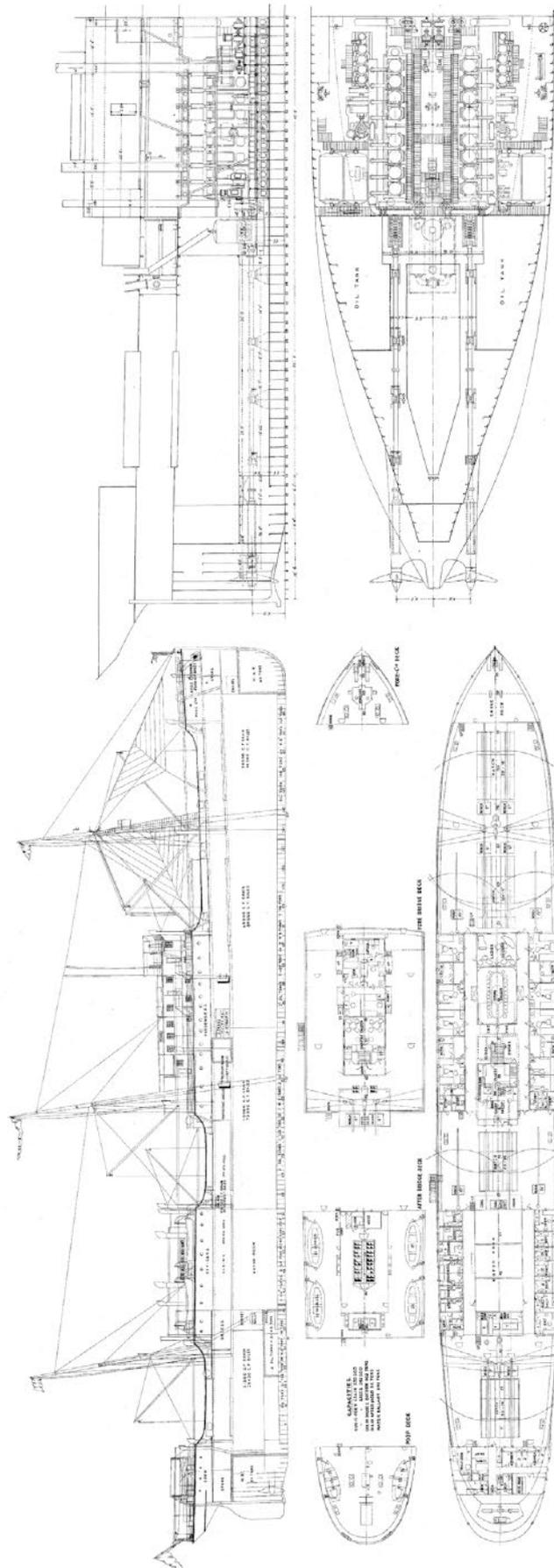
A delegate from the Royal Navy said an economical engine would be welcome, particularly for commerce protection vessels that could stay at sea for months without refuelling. Some existing steam warships of this type were coal eaters and we did not get what we wanted out of them." He also raised the question of oil supply and storage. "We have our coal – at least we hope we have got it- although we cannot get at it just now owing to the strike – but how about oil fuel?"

It happened by coincidence that *Selandia*'s London visit occurred during a coalminers' strike and coal shortage, sharpening awareness of marine fuel supply. Countries without fossil fuel could adopt the motorship

with an open mind, but the UK, sitting on huge resources of high quality coal, had built a great coal distribution system along the world's sealanes, and a powerful coal and steamship lobby that spent decades resisting the encroachment by motorships. But the Navy was already making the big decision to use oil fuel in major warships to improve availability, getting away from the frequent labour intensive and prolonged bunkering of coal, and the government was setting up the strategic arrangements to secure supplies.

EAC's faith in the diesel engine proved well-founded. *Selandia* had a long career, with EAC until 1934, eventually being wrecked off Japan in 1942 after several changes of ownership. *Fionia* was successful in a different way. Within weeks of delivery from B&W it went to Germany, and was bought by Hamburg America Line, who had already ordered motorships that had not yet been delivered. *Fionia* was scrapped in 1939. The third vessel in the trio had been ordered from a Scottish yard that had built good steamships for EAC. But they had greatly underestimated the level of precision needed to make a successful large marine diesel (one comment was that they didn't recognise any measurement less than a sixteenth of an inch), and engine troubles delayed delivery. But *Jutlandia* later had the distinction of being the first EAC ship to transit the newly opened Panama Canal in 1914, and was possibly the first large merchant motorship to do so. [NA](#)

GA of Selandia



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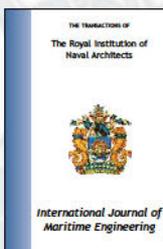
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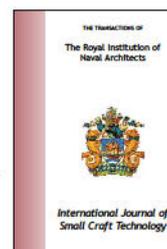
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