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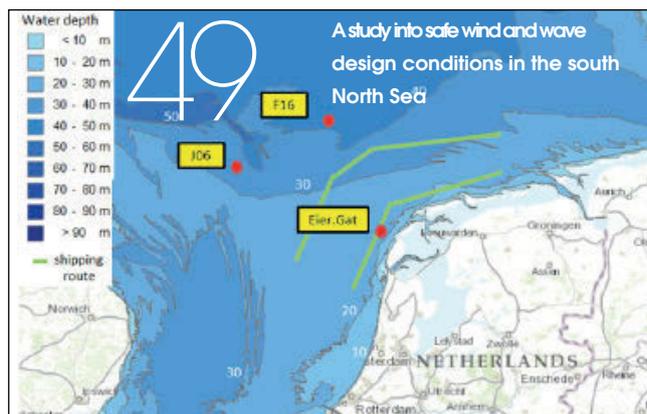
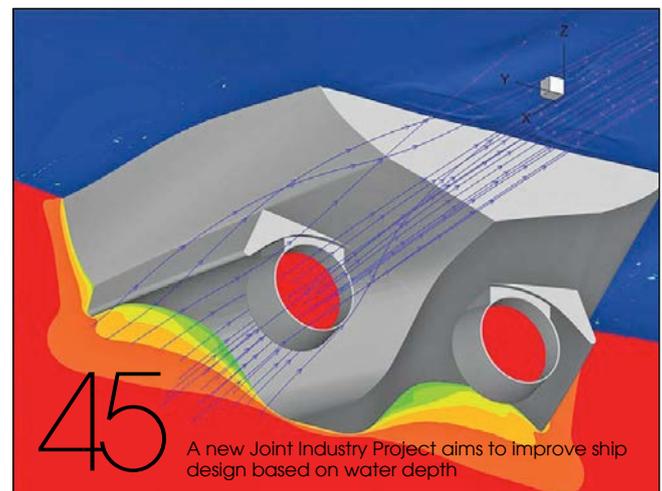
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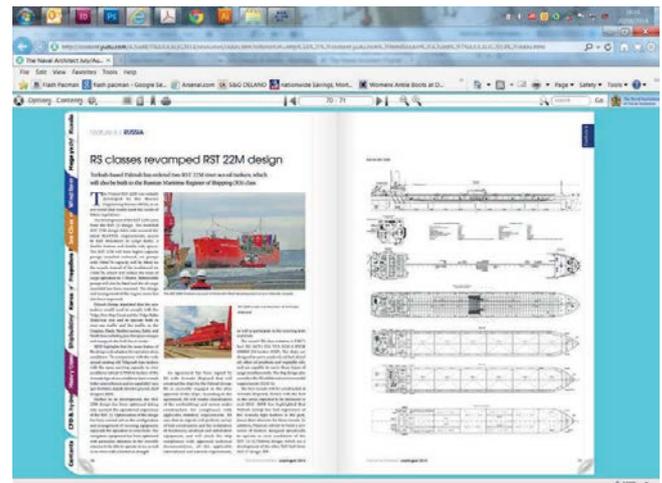
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Stories to be told

Moby Dick author Herman Melville plaque in Covent Garden, London

Less than a minute's walk from RINA's London headquarters, in adjacent Craven Street, stands a house where the author Herman Melville briefly lived in 1849 (at the time of writing the property is on the market... if you have £5 million to spare!). Melville's work, most memorably his opus *Moby Dick*, is heady with the romance and melancholy allure of the sea and he drew inspiration from his own formative years as a deckhand on-board whaling boats and later as a clerk for the US Navy.

In the 19th century, shipping was both the only means of long-distance transportation and a natural career choice for the adventurously minded. But in the early 21st century, attracting people to maritime, or perhaps more specifically the right sort of people, has become one of the major concerns of the industry. Whether on the bridge, in the engine room or in a land-based role, the 'mariner' risks becoming flotsam in the tide of technological change and overwhelmed by the drudgery of regulatory compliance.

In early September, I was just across the road from Melville's old lodgings at an event hosted by ABS as part of the third biennial London International Shipping Week. The topic was 'Preparing People for Smart Shipping' and the panel debated how training and educational needs should be adapted to the demands of 'disruptive' change. Predictably, two of the major impedi-

ments were felt to be shipping's lack of public awareness by comparison with other industries and a generational shift in attitudes. "Millennials are looking for quicker gratification," reflected one of the panellists, Mark Cameron, vice president and COO of Ardmare Shipping.

This may be true, to some extent, but like Melville, few young people are mere hedonists driven by the pursuit of material comfort. The high cost of living, concerns for the environment and antipathy towards big business are also shaping attitudes and leading them to pursue something more meaningful, and for developing economies, national pride is a bigger factor than those western societies in the throes of affluenza.

The difficulty facing shipping has become the same as that of engineering and other technical professions in attracting new recruits, namely that progress requires years of study, training and then ongoing education to keep abreast of the latest developments, often across different specialisms. For example, the young naval architect who also has a firm grasp of computing principles (or indeed automation systems — see p.42). Moreover, whether at sea or on land, it demands that they learn to process facts and data quickly and critically, and have the wherewithal to know when it's best to seek advice from elsewhere.

That's a challenge in the best of worlds, let alone during a prolonged

period of downsizing and consolidation, as maritime has faced. Few shipping companies are in the enviable position of Maersk to be able to invest heavily in apprenticeship programmes that allow recruits to realistically envisage their long-term futures at a single company.

You have to wonder who's really in control and there's a certain irony that technologies such as remote and autonomous shipping, once futurist fantasies, are now perceived as a panacea. But autonomous shipping, likely though it is to begin on a limited scale in the next couple of years, won't resolve shipping's PR problem. Indeed, is it really where priorities ought to lie in the face of the growing threat from climate change? Cameron made perhaps the most salient observation in the debate when he expressed the view that money would be better invested in emissions management and that this is where more enquiring minds were needed.

"The industry will really change when the reciprocating engine is unlocked," he added. Environmentally and technologically this is probably true, but equally important will be a change in attitudes towards education and maybe the world in general. That's not just a problem for shipping, but for society in general. The age of buccaneering adventure on the high seas may be long over, but there are still important stories to be written. *NA*

LNG

Carrier vessel first to bunker with LNG in UK

LNG provider, Flogas, and Associated British Ports (ABP) have joined forces to bunker a ship with LNG for the first time ever in the UK. The 110m carrier, *Ireland*, which is operated by Norway-based KGJ Cement AS, completed the bunkering at the Port of Immingham on 16 August this year.



The carrier vessel, *Ireland*, bunkered at the Port of Immingham

Managing director at Flogas, Lee Gannon, is optimistic that the milestone is a sign of things to come: “At Flogas, we pride ourselves on leading the way when it comes to developing the LNG industry in the UK, and exploring new opportunities for end users to benefit from this highly versatile fuel. There is great potential for LNG in the maritime industry as a more environmentally-friendly alternative to traditional oil-based bunker fuels, but until now this potential has remained untapped here in the UK.”

With the IMO’s emission regulations imminent, it’s expected that the demand for LNG will increase, and so too the need for bunkering facilities in the UK. Mark Frith, port manager for ABP Immingham and Grimsby, adds: “Demand is already beginning to shift away from oil across the international fleet, and we very much see natural gas taking its place as the marine fuel of choice. We look forward to welcoming increasing numbers of ships to Immingham as a result of our new and unique offering in partnership with Flogas.”

The tanker-to-ship service currently in operation at Immingham is sufficient for the current demand for LNG bunkering, but Flogas plans to invest in storage and further bunkering facilities at various ABP ports as demand increases over the coming years.

Filtration

Bollfilter wins case against OceanSaver AS

OceanSaver AS’s claim for compensation against Bollfilter Nordic ApS, Denmark, for the company’s supposedly faulty filters has been fully dismissed by an arbitral award.

The case concerned filtration machines which had been developed and manufactured by German Boll & Kirch Filterbau GmbH, which formed part of OceanSaver’s ballast water treatment system, sold to shipyards in China and South Korea by OceanSaver.

OceanSaver claimed that the filtration machines with mesh wire filters, which were delivered by Bollfilter Nordic ApS in 2010/2011, were defective and so had caused the filtration system to not work properly following installation. However, Bollfilter maintained that its machines had been thoroughly tested and was confident that the malfunction was not down to the filtration machines, but rather due to other factors, such as inadequate piping on board.

After four years, the arbitral tribunal decided in favour of Bollfilter based on evidence supplied. OceanSaver has been ordered to pay all arbitration costs as well as Bollfilter’s legal costs.

CEO of Bollfilter Nordic ApS, Robert Jellinggaard, says: “The filtration machines manufactured by Boll & Kirch Filterbau GmbH are successfully installed in hundreds of ships around the world, and we never doubted that we would win the arbitration case. Our automatic filters for ballast water stand for first class quality. We are very happy that this dispute has finally come to an end, and we are looking forward to again spending all of our time and energy on working with our many customers rather than in a courtroom.”

Eco ship technology

Project to build world’s biggest sailing cargo ship

A new sustainable shipping project, *Quadruga*, aims to build the world’s largest sailing cargo ship and already has Lloyd’s Register on board.

Born from Hamburg-based sustainable shipping company, Sailing Cargo, the project plans to build a 170m-long car carrier, able to carry between 1,700 and 2,000 cars. The unique design will feature four DynaRig masts and will operate on hybrid propulsion with sails and diesel-electric engines. There will also be an optional battery system to supply energy for peak loads.



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The vessel will employ wind-assisted propulsion and a battery system for peak loads

The vessel will initially sail at 10-12 knots, but it's hoped that it will reach speeds of 14-16 knots in the next few years.

Uwe Köhler, founder of the Quadriga project, says: "We must do the right thing for the future of our industry; the Quadriga project combines traditionally proven systems with cutting edge technology and aims to provide a solution to reduce CO₂ emissions. We are delighted to be working with Lloyd's Register on this project."

Lloyd's Register's Low Carbon Pathways 2050 study found that low carbon vessels will need to be in operation by 2030 if the industry is to reduce its emissions in line with the Paris Agreement. To make such significant changes in the industry in this time, it's expected that engineering advances alone, to improve efficiency, will not be enough and so it is hoped that the Quadriga project will provide a realistic alternative solution.

Lloyd's Register will ensure compliance with all technical, safety and environmental standards through consulting on the design and supervising onsite construction and will also verify whether predicted performance parameters set have been achieved by the project.

Class societies

New IACS chairman outlines plans for the future

IACS's new chairman, Knut Ørbeck-Nilssen, announced a number of initiatives the organisation will be introducing at a press conference last month. The proposed actions include reinforcing IACS's role as a leading technical association, deepening its commitment to transparency and preparing for the new digital era of shipping.

IACS will review and amend its membership criteria, for both new and existing members. According to Ørbeck-Nilssen, no current members are in danger of being expelled, but the more stringent criteria will ensure standards are heightened and maintained.

Ørbeck-Nilssen will also aim to work with the IMO and flag states to speed up the process of electronic

certificates being deployed. He added: "Digitalisation is changing not only the way the shipping business is being conducted, but the systems themselves and the way they interact together. Because of this, Class needs to be adaptable and flexible in our delivery and thinking. IACS members should be enabled to provide the services that our stakeholders require in the digital age, as these are essential for competitive and safe operations."

The association plans to extend the length of its strategic plan to five years, so that it aligns with the IMO's timeline, and will publish an annual report in the first quarter of each year to increase transparency. As of yet, there are no plans to extend the chairmanship from one year to align with the new strategic plan.

The modernising of survey methods, including the use of drones, was also discussed and Ørbeck-Nilssen plans to begin a review of IACS Resolutions to update them and remove anything that might prove an obstacle to new technologies like autonomous shipping.

Sweden

MAN Cryo to build LNG bunkering facility in Sweden

MAN Diesel & Turbo's marine-LNG fuel-gas-system manufacturer, MAN Cryo, is partnering with gas supplier, Swedegas, to deliver the first LNG bunkering facility at the Port of Gothenburg, Sweden.

The facility, on schedule to start operating next year, will provide increased flexibility to customers and LNG suppliers at the largest port in the Nordic countries. Vessels will be able to load and unload cargo, at the same time as bunkering LNG from trucks or containers, at two jetties at the Swedish port's Energy Port, meaning there will be no need for a separate refuelling stop.

Mikael Adler, managing director of MAN Diesel & Turbo, Sweden, says: "We are very happy to have won the contract to build this first such bunkering facility in the important Port of Gothenburg. Our strategy to offer LNG solutions to the marine market, both on board vessels as fuel-gas supply systems, but also as bunkering infrastructure, dovetails perfectly with the general development towards cleaner ship propulsion."

The build will be overseen by MAN Cryo, under the terms of an EPC contract, and the finished facility will be operated and managed by Swedegas, in cooperation with the Port of Gothenburg. Plans for the facility include a discharge station for LNG trailers and containers, bunkering equipment, feeding pumps and vacuum-insulated piping. So important is the venture that it has been designated as one of the highest priority infrastructure projects in Europe by the EU. **NA**



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Talk turns to action for autonomous ships

From being little more than an interesting but ultimately uncommercial sideshow, autonomous ships have gathered a lot more advocates as the number of projects and research programmes grow, writes Malcolm Latarche

Until this summer the concept of autonomous ships was very much a paper exercise, but there have now been two demonstrations of the possibilities using existing vessels — a tug and an offshore vessel — with a third using a containership on the way, plus an intended order for a commercial ship announced in May this year.

The tug trials took place in June and involved Rolls Royce and the Danish towage company Svitzer. During the trials, a tug master at the owners' headquarters successfully stationed the 28m tug *Svitzer Hermod* alongside a quay, undocked and manoeuvred it before piloting it back to base. Rolls Royce and Svitzer have agreed to continue the test programme and expand its scope testing aspects of autonomous navigation, situational awareness, remote control centre and communication.

In the second remote manoeuvring test, Wärtsilä was testing its remote control systems on the 80m PSV *Highland Chieftain*. This was arguably a little more impressive than the tug project as the remote command post was in California and the vessel in the North Sea off the coast of Scotland. The test was conducted over an almost four-hour period, during which time the vessel was driven through a series of manoeuvres at both high and low speeds. Significantly, this was achieved using standard bandwidth onboard satellite communications equipment and no land-based technology was used for the communications between the vessel and the remote operator work station.

Although Wärtsilä's Dynamic Positioning (DP) unit developed remote control capabilities in the early part of 2016, this was the first test carried out on an operational ship. For the test, additional software was temporarily added to the DP system in order to route data over the vessel's satellite link to the onshore work station in California. Highlighting how quickly the transition from conventional ship to remote operation can be, the retrofitting of the DP software was completed within just 30 hours.

The containership test is as yet a little way off being pencilled in for 2019. It will see NYK Line remotely controlling one of its vessels from Japan to a US port. The voyage is being planned by the Monohakobi Technology Institute, which is a subsidiary of NYK.

With so much practical activity, it was almost certain that the issue of autonomous ships would feature prominently during London International Shipping Week, which took

place in early September and had 'Tomorrow's Maritime World' as its theme. While there were no practical demonstrations taking place, there was plenty of discussion and the release of a new report produced by Lloyd's Register, QinetiQ and the University of Southampton.

There have been several comments in online blogs about the subject of autonomous ships, with several contributors questioning the economics and desirability of the concept. There is obviously a fear for seafaring jobs underlying some of these — something that is being addressed by the officers' union, Nautilus International, at a conference in Hull this month. But others argue that the supposed savings are an illusion and that there has been too little thought given to issues such as machinery failure and the ability of a ship to offer assistance in case of a collision or other incident.

Few would argue that naval applications are best suited to autonomous ships and in that regard, Rolls-Royce has recently revealed plans for an autonomous, single role, naval vessel with a range of 3,500 nautical miles. The vessel concept is capable of operating beyond the horizon for over 100 days, will displace 700tonnes and reach speeds above 25knots. The 60m-long vessel is designed to perform a range of single role missions, for example, patrol & surveillance, mine detection or fleet screening.

The initial design features a full electric propulsion system that features two Rolls-Royce MTU 4000 Series gensets providing around 4MW electrical power to a 1.5MW propulsion drive. An alternative to diesel engines could be small gas turbines, further improving the system's reliability and reducing onboard maintenance.

In announcing the concept, Rolls-Royce acknowledged one of the criticisms often directed at unmanned ships with regard to the need to monitor, operate and repair machinery. It said the absence of crew increases the need for very reliable power and propulsion systems. Rolls-Royce's approach is to blend advanced Intelligent Asset Management and system redundancy in a cost-effective manner that avoids sacrificing the cost and volume savings achieved by removing the crew.

That may work for naval vessels, but whether commercial operators will be induced to invest remains to be seen. The economics should also take into account that remote control centres can be taken offline quite easily by power outages so the redundancy will need to extend to these facilities also. [NA](#)

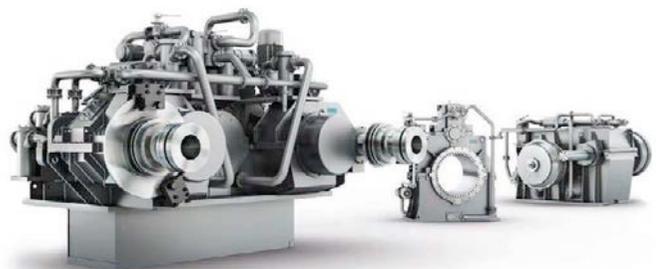
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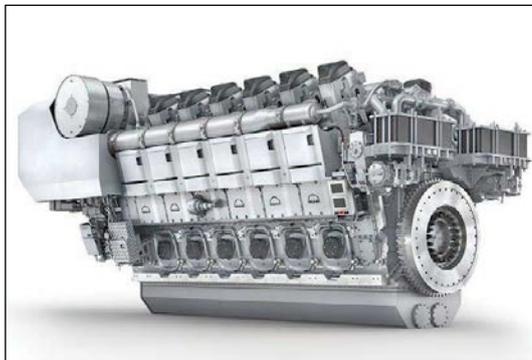
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Engines

MAN unveils new high-performance engine

MAN Diesel & Turbo has revealed a new marine diesel engine that will join the company's line of 4X high-performance diesel engines. The MAN 45/60CR, successor to the 48/60CR, will firstly be available in 12V and 14V versions, with power outputs of 15,600kW and 18,200kW respectively. 6L and 10L variants are due to follow.

With its increased power and low fuel consumption, the engine is especially suited to cruiseships, ro-pax ferries, ro-ro vessels and dredgers. The design also features a two-stage turbocharger module, with a low-pressure and high-pressure turbocharger arranged in series, helping the engine to achieve excellent efficiency.



The MAN 45/60CR engine will be most suited to ro-pax and ro-ro vessels

Dr Gunnar Stietsch, head of engineering engines at MAN Diesel & Turbo, says: "Next to a frontloading approach, using thermodynamic engine process calculations, we used computational fluid dynamics to simulate and optimise the combustion process. Also, finite elements analysis was used to optimise the engine's mechanical strength and vibration behaviour. We then put the power unit to the test on the world's largest, four-stroke, single-cylinder test engine and started the experimental optimisation and validation phase."

Based on a representative load-profile of a cruiseship, calculations show that a vessel equipped with a MAN 45/60CR engine can offer a fuel-oil cost benefit of 5-12% when compared with a vessel running on an equivalent engine from another manufacturer. For a cruiseship of between 120,000 and 150,000gt, with 60-65MW and a fuel price of €500/tonne, this could amount to a saving of between €900,000 and €2.4 million per year.

The four-stroke engine meets IMO Tier II (the company's SCR system satisfies IMO Tier III) and is waiting on approval from all major classification societies. The first V-type engines will be available from the end of 2020, and the first L-type engines from 2022.

www.dieselturbo-uk.man.eu

Engines

Wärtsilä and ABB sign service agreement

Technology giant Wärtsilä and ABB Turbocharging have signed a six-year service agreement, granting Wärtsilä Authorised Service Provider status for the maintenance and performance optimisation of ABB turbochargers installed in Wärtsilä 4-stroke engines.

The two companies will share service data and maintenance documents to ensure the smooth running of all services and Wärtsilä's new Authorised Service Provider status for standard maintenance will allow the company's personnel to disassemble, exchange parts, balance and reassemble ABB turbochargers fitted in its 4-stroke engines.

Tomas Hakala, vice president, 4-stroke engine services at Wärtsilä Services, says: "Being able to look at the whole installation increases its availability and efficiency, optimising service speed and agility. Customers can reduce their operational risk, ensure optimal tuning and save time by being able to overhaul their ABB turbocharger at the same time as the engine. Wärtsilä's aim is to expand its leadership as a global provider of quality services also to turbochargers. Thanks to this agreement, we are now able to serve our customers even better by offering them ABB turbocharger services, coupled with our engine know-how, across 25 locations."

There will also be 25 authorised Wärtsilä turbocharger workshops offering an expanded service, adding to the 110 ABB Turbocharging Service Stations that are already running in various locations around the world.

The agreement aims to benefit customers by enhancing performance optimisation over engines' lifecycles and being able to increase the reach and availability of maintenance services. The partnership between Wärtsilä and ABB also highlights both companies' efforts to develop and market upgrade and retrofit packages for the 4-stroke engines, with over 100 upgrade solutions — designed to improve fuel efficiency, increase uptime and reduce operational expenses — having already been commissioned before 24 August this year.

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SeaCURE BWMS completes USCG Type Approval tests

Evoqua Water Technologies' electrochlorination-based SeaCURE ballast water management system (BWMS) has successfully completed all biological efficacy US Coast Guard (USCG) Type Approval tests.

The tests, which have been on-going since 2015, were carried out by NSF International and under the supervision of Lloyd's Register. NSF International was the first independent laboratory to be certified by USCG for BWMS testing and is known for its stringent testing regime, so asking them to carry out the tests was a strategic choice, as Ian Stentiford, Evoqua's global vice president, electrochlorination, explains: "We deliberately selected an independent laboratory that would challenge the SeaCURE system as part of the whole approval process. The testing NSF partners carry out is extensive and places considerable demands on the system in real-life, operational conditions. Testing uses real organisms, in different salinities, different water temperatures and different local environments, taking into account organism regrowth.

"It is very stringent; but we knew that if the SeaCURE system could pass these tests, then shipowners will be confident that the system they

SeaCURE is one of the smallest electrochlorination-based BWMS to have complete USCG testing



have invested in is very robust and it can actually do what it has been designed for in all at-sea operating conditions encountered."

The first five tests, conducted in summer 2015, were carried out by NSF partner, Maritime Environmental Resource Centre (MERC), in brackish waters in Baltimore harbour. The next five freshwater tests were carried out by Great Ships Initiative (GSI), another of NSF's partner laboratories, during the following summer. The tests were concluded with land-based tests (marine water), conducted by Marine Eco Analytics (MEA-nl) and Lloyd's Register on 27 July 2017. Shipboard testing was completed in various locations worldwide with MERC's scientists.

NSF International will now compile the test data for submission to USCG, with Evoqua anticipating that the system will receive BWMS Type Approval before the end of the year.

www.evoqua.com

Software

STM systems installed on first vessels

Sea Traffic Management (STM) compatible bridge systems have successfully been installed on three operating vessels.

The system, which connects ships with shore-based services, is already working well on *Stena Germanica* and Swedish Sea Rescue Society (SSRS) rescue ships *Rescue Märta Collin* and *Rescue 11-00*.

Its functions include route optimisation, synchronised port calls and it can even send and receive route segments to and from other ships. Developed as part of the STM Validation project, route information is transmitted to other ships via AIS, with an officer of the watch able to see up to seven route segments of other ships, allowing them to precisely pinpoint meeting points and closest point of approach (CPA) so that they're able to avoid potentially dangerous situations.

Anders Rydlinger, director for ship solutions at Transas, says: "Through information sharing between ship and shore, using the Maritime Cloud/SeaSWIM infrastructure, we are creating a cohesive community, which enables better communications and joined-up decision making. This leads to higher operational standards, greater environmental performance, increased efficiency and improved safety record."

The STM Validation Project will demonstrate the STM concept in large-scale test beds, to include 300 ships, 13 ports and five shore-based service centres.

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Fairy tale — or tomorrow's reality?

Advanced thinkers from research laboratories, maritime authorities and industry met to offer a sneak preview of the future of the maritime industries at the HIPER conference in Zevenwacht, South Africa, in September. Conference organiser, Volker Bertram, reports

Technologies for Future Ships and Future Shipping was the theme of the 11th High-Performance Marine Vessels (HIPER) conference. The main insights from the 2017 conference were:

- Fusion of Big Data and simulation — Digital Twins are the backbone of future shipbuilding and operation. Add (simulated) behavior models to 3D product data models and you get Digital Twins. Virtual reality and sophisticated simulations give the Digital Twin a look and feel like the real deal and Big Data from ship operation ensures that the twin follows his real counterpart through life, e.g. in terms of degrading strength and hull performance.
- Yards get smart — smart yards ('Shipyard 4.0') are evolving, where production is simulated and optimised before the plate is even cut. Augmented reality helps workers to become more efficient and make fewer mistakes. Plus the 'as-built' state of the ship is tracked as the ship is assembled, with 3D scans playing a key role.
- Cleaner, greener ships — heavy fuel oil has ruled supreme for decades. The old

empire is now divided among a multitude of successors. Hybrid propulsion will be the new normal. Fuel cells and batteries will furnish auxiliary power and even propulsion power (for smaller vessels). Renewable energy is slowly, but steadily, gaining traction.

- Smart ships now, autonomous maybe later — ships are getting smarter with ever more sensors and 'edge computing', i.e. data processing at the source rather than in the cloud. Big Data gets reduced to small-to-medium data on board, delivering faster insight that can quickly be put into action — this is already happening. The unmanned cargo ship is still a long way off, but autonomy progresses in many smaller systems and vessels. Maritime authorities are preparing for the time when marine traffic will comprise of an arbitrary mix of traditional ships, partially-autonomous ships and unmanned (remotely-operated) ships.

Goodbye design spiral?

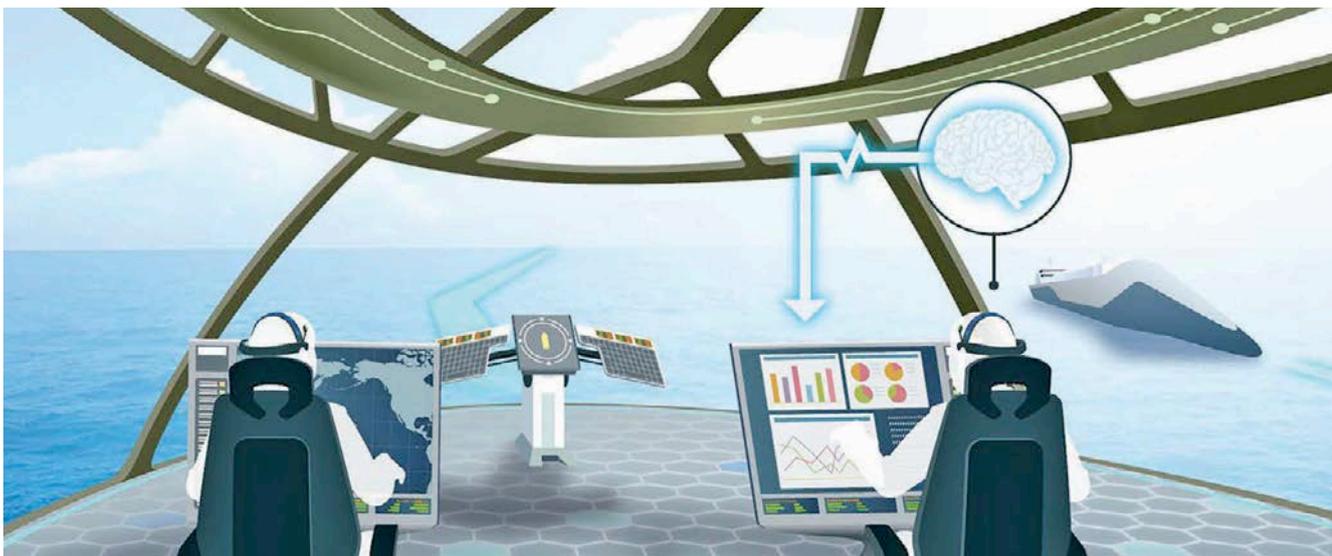
'I can see clearly now' was the title of Herbert Koelman's, of SARC, Netherlands, keynote

lecture on future ship design methods. It was music to my ears. Many of his views matched those of my own presentation 'Ship Design Technologies: A CAVE-man's View'. I believe it's time to mothball the (pre)historic design spiral — ship design is not that straightforward. Instead, we need to realise that every activity can be performed an undetermined number of times in an arbitrary sequence. Design is getting more concurrent and the way computers support us must reflect this. And, while we are at it, 2D design is an anachronism, destined for obsolescence.

But while we can relegate some ship design features to the museum, others are bound to stay. Unfortunately, the eternal interface issues are bound to stay with us. Koelman set the tune with "Don't let me be misunderstood." No, this is not a typo, it was his way of illustrating the point. Simply copying the music title from a web browser to his Word file caused the text to become garbled. Koelman says: "Apparently, mankind is not able to transfer a line of text from one program to another, but we still expect that 3D product models can be communicated

30 years from now ship computers may be directly controlled by our brains

Source: NMRI



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meaningfully? The remarkable thing here is not that shit happens, but that people persist in expecting flawless program interoperability.” Point taken — interface problems are bound to stay with us. Deal with it!

Another ship design tradition is also likely to remain — the time-honoured conflict between real-world experience and virtual experience gained from simulations. Stein Ove Erikstad of the Norwegian University of Science and Technology (NTNU) had a look at the old conflict in new a guise in a presentation named ‘Merging Physics, Big Data Analytics and Simulation for the Next Generation Digital Twins’. Big Data in this context stands for empirical approaches, Digital Twin for simulation. The future, said Erikstad, will lie in experience and simulation capabilities and combining the strengths of each approach.

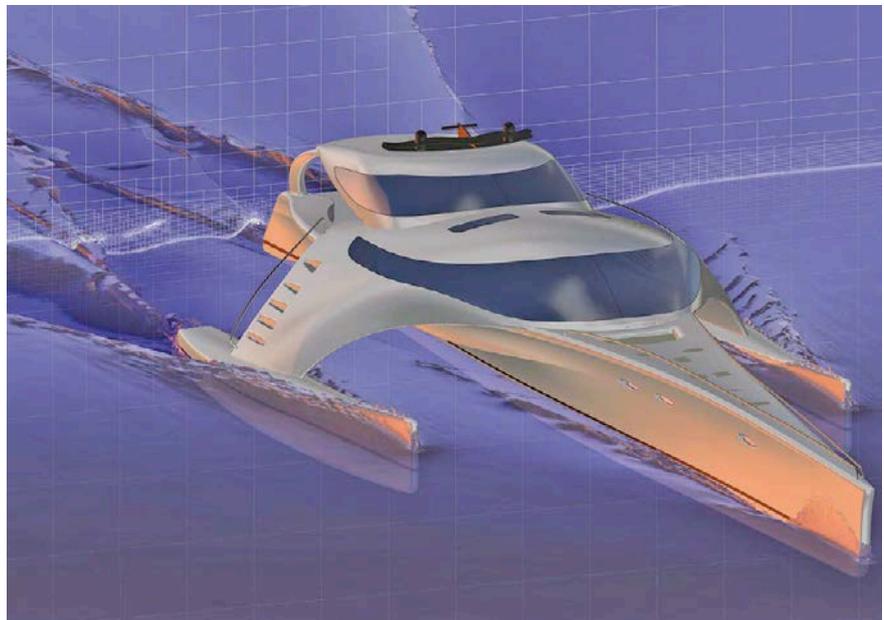
Digitising services changes the way we do business and possibly our business landscape. For model basins, a paradigm change seems to be written on the wall. Cloud computing, flexible licensing schemes and software connections are bringing a “democratisation of high-performance marine CFD”, in the words of Thomas Hildebrandt, Numeca. The occasional users in small design offices or shipyards will welcome this new business model. But, there is still a big hurdle — the know-how to use the CFD software properly, mainly how to make grids and how to choose process control parameters to get sufficiently accurate results in a sufficiently short time. Here, Karsten Hochkirch, DNV GL, took the idea one step further in ‘Cloud-Based Numerical Towing Tanks: Anytime, Anywhere and for Anybody’, a paper that was published in full in last month’s *The Naval Architect*. Having your design tested is now just a credit card and a few clicks (and geometry upload) away. Disruption is in the air.

Greener, smarter, safer

HFO was yesterday, LNG as a fuel will take the lead from now — it’s a prophecy we’ve heard ad nauseam, but there are some other smart ideas waiting in the wings. Keno Leites, TKMS, described fuel cells with up to 500kW power output and 50% efficiency — and they are based on low-Sulphur fuel. Kites for wind assistance may not yet soar, but have been given a second wind with the French ‘Beyond the Sea’ initiative led



Digital Twins compile knowledge from simulations and Big Data analytics Source: DNV GL



The power of the cloud allows faster designs — especially for unconventional concepts Source: Numeca

by Yves Pallier which aims to develop very large kites for ship propulsion. Meanwhile, Hironori Yasukawa’s, Hiroshima University, idea of using fins to convert ship motions into thrust may seem far-fetched, but the savings of more than 8% proven in model tests are real.

Then we come to the murky domain of antifouling. There is broad consensus that the future here is biocide-free, but how? Bertram, DNV GL, and Diego M. Yebra, Hempel, discuss assorted alternatives in a keynote paper. One of the new contenders is ultra-sonic protection, as presented by Jan

Kelling, Hasytec, who won the ‘Maritime Innovator Award’ at HIPER (and also featured in last month’s *The Naval Architect*). The South African navy is interested in the technology. No wonder, as ultrasonic protection works also when the ship is idle for a long time, as naval ships tend to be. This may be an example of a disruptive technology that comes along quietly.

No futuristic scenario would be complete without the ‘unmanned ship’. Svein Medhaug of the Norwegian Maritime Directorate discussed the ‘Future of Autonomous Shipping from an Administration Point of



Drone-based inspection has entered industry applications

Source: DNV GL

View’, concluding that autonomous shipping would be seen first in national waters, implicitly throwing his hat in for Norwegian waters. However, there was more focus at the conference on smart ships, full of sensors and using Big Data or possibly ‘edge computing’ (on-board data processing to reduce data amount and gain faster insight where it is needed for operation — on board). The latest South African polar research ship, *SA Agulhas II*, is one of the new generation of smart ships and Annie Bekker of Stellenbosch University explained how its data gathering is used to improve operations. John Fernandes, Nelson Mandela University, discussed future Totally

Integrated Automation (TIA) on ships and its training implications. With ‘Maritime Training 4.0’ classical mock-ups of engine rooms can be operated online with webcam supervision. This prototype installation in a South African maritime university echoed ideas of future web-based training presented by Tracy Plowman of DNV GL’s Academy in ‘Maritime e-Training – Matching Requirements to Solutions’.

Visionary keynote from Japan

The boldest and most visionary contribution came from Kohei Matsuo of the National Maritime Research Institute

of Japan, who looked at possible scenarios for future ships and shipping 30 years into the future. Here the borders between science and fiction became fuzzy. Matsuo deservedly received the conference’s ‘Inspiring Visionary Award’, and will be featured in next month’s *The Naval Architect*.

Bill Gates once said: “We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten.” How much more will we then fall short when we look at 30 years? Not much risk here when we look at Matsuo’s vision: ships may be made of carbon nanotubes, making them extremely lightweight; ships may be completely 3D printed, just as some houses now; ships and cargo will have embedded sensor supporting the Internet of Things and largely or completely automatic handling in port; augmented reality for intuitive instruction of workers in shipyards may just be a bridging technology to uploading knowledge and skills directly from computers to the human brain; zero-emission ships will be based on hydrogen technology, using hydrogen as high-density storage for wind, tidal, wave and solar energy and ships may be floating factories adding value to the cargo in transit.

What sounds like science fiction is a national research project identifying key technologies for the maritime industries, extrapolating avant-garde R&D and interviewing a multitude of experts.

A bright future ahead?

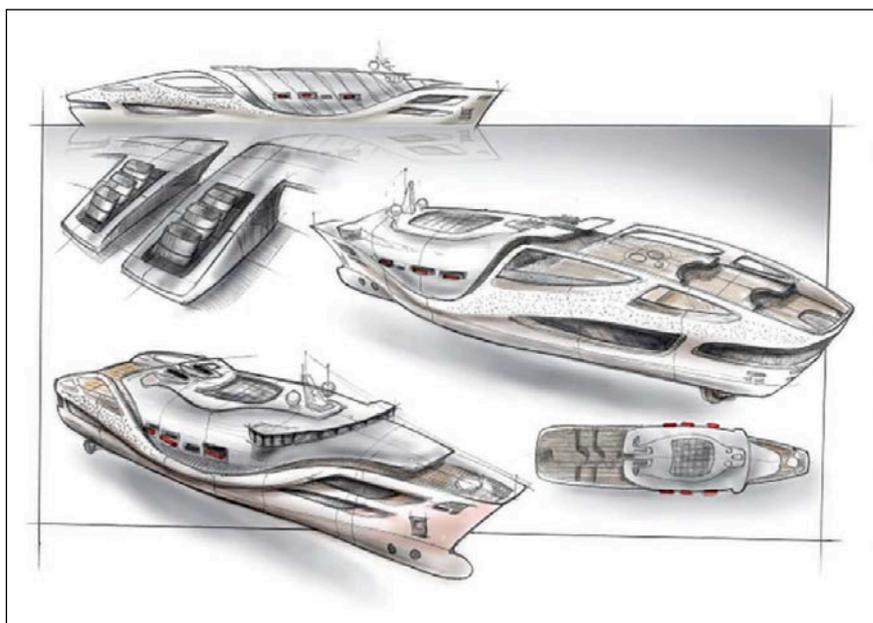
“A bright future may lie ahead, but will not arrive without pursuing it. [...] The scenarios can only become reality if we actively contribute [...] and stimulate others to do so, too,” says Koelman. Perhaps I have been able to do my bit for the bright future and stimulate you to download the HIPER 2017 proceedings for free at www.hiper-conf.info. Happy reading! **NA**

About the author

Volker Bertram is a German naval architect and professor at Stellenbosch University, Department of Mechanical and Mechatronic Engineering.

While the future may remain sketchy, it looks intriguing

Source: Politecnico di Milano



Jiangsu shipbuilding industry: market segmentation and the battle for survival

By adopting flexible marketing approaches, striving towards transformation and upgrading to resolve the crisis, shipyards in Jiangsu Province are winning the tug of war for orders and maintaining smooth and steady development in production and operations

Since the international financial crisis, the global shipbuilding industry has fallen into a 'cold winter' and many shipbuilding enterprises are facing grave challenges for survival due to complex and volatile domestic and international situations, sluggishness in the shipbuilding and offshore engineering markets and the negative impact of difficulties in orders, financing and delivery. Faced with these challenges, however, the private shipbuilding enterprises in Jiangsu Province — relying on the innovation drive in their own system and the capacity of rapid market adaption — have adopted the strategies of market segmentation and dislocation competition.

Segmenting the market to gain orders

Along the shoreline of the Yangtze River in Jiangsu province section, Jiangsu Yangzijiang Shipbuilding Group, Jiangsu New Times Shipbuilding Co. Ltd, China CSSC Chengxi Shipyard Co. Ltd, Sinotrans & CSC Jinling Shipyard and other shipbuilding enterprises are found, and in terms of geographical location, these companies are either next door neighbours or facing each other across the river. Despite fierce competition in the marketplace, these companies are doing well in their own way and the overall trend is one of a common development with motivating rivalry.

The main reason for this is that these enterprises, taking advantage of their own strengths, have actively segmented the market and focussed their expertise on particular shipbuilding or ship type sections so as to create their exclusive brand. At the same time, the companies have also made a great effort in research and development of high-tech, high value-added ship types and have achieved successful breakthroughs



The world-first 'Dolphin 64' green bulk carrier, *Amber Champion*, built by CSSC Chengxi Shipyard

in business, based on an approach that is guided by science and technology and supported by a quality brand.

In recent years, AVIC Dingheng Shipbuilding Co. Ltd has successfully delivered many small and medium-sized liquid cargo vessels. The market reputation gained and experience accumulated in technology, production, process and management have enabled the company to break the market monopoly of Japanese shipbuilders in small and medium-sized chemical ship segments. At present, the company has grown to be the world number two in small and medium-sized chemical tankers of less than 30,000dwt.

Based on the segmentation of the international ship market, Yangzijiang Shipbuilding Group has made full use of the great opportunity of workforce flow due to the downturn in shipbuilding and has recruited a large number of R&D personnel. In order to meet the growing demand for new energy transport vessels and new energy powered ships, as well as the potential market demand for special vessels and ultra-large energy-saving dry bulk carriers, in 2016, the group invested more than 300 million yuan (US\$46 million) in R&D for the development of a dozen or so

new high-tech ship products. The effective supply of energy-saving, low emission and highly smart ship products has created new market demand.

China Shipping Industry (Jiangsu) has accelerated the transformation and upgrading of its facilities to improve its shipbuilding and actively explored the international ship market. The successful construction and delivery of a 9,400TEU containership signifies that the capacity of the company to build large, high quality and new ship products is on a par with the advanced domestic and foreign shipbuilding enterprises.

Adjust strategy for full transformation

In Jiangsu, a number of shipbuilding companies have firmly grasped the opportunities created during the international market adjustment and won in the marketplace through company transformation and product renovation to meet new market demands.

Under the guidance of the development principle of 'innovation, harmony, green, open and sharing', Jiangsu New Times Shipbuilding Corporation has concentrated on high-tech and high value-added ships, such as chemical tankers and product tankers, as its main

business. The attention and research are focused on the energy saving, environmental protection and comfort requirements of the ships. Considering new materials, ship optimisation is conducted with a choice of clean energy and green materials in accordance with international standards. Following the approach of intelligent and green production, the core competitiveness of the company has been greatly enhanced and the ability to withstand market volatility has also been continuously strengthened. In 2016, New Times Shipbuilding Corporation took proactive actions to talk to shipowners with the aim of seeking orders and capturing the market share. The company successfully obtained new order intention for 22 ships, including a 320,000dwt VLCC super tanker, which has provided good support for the sustained and steady development of the company.

Facing the weakness of the mainstream ship market, CSSC Chengxi Shipyard Corporation has targeted the market segments of asphalt carriers and chemical tankers. On the basis of further market research, three types of asphalt ships and one type of chemical tanker were



A dock in CSSC Chengxi Shipyard

developed jointly with design institutes. These have successfully attracted business orders and have enabled the company to continue with its product transformation. In addition to trying to excel in traditional repair, construction and non-ship products, the company has made greater effort to promote the products for market segments of multi-purpose ships and pulp cargo ships.

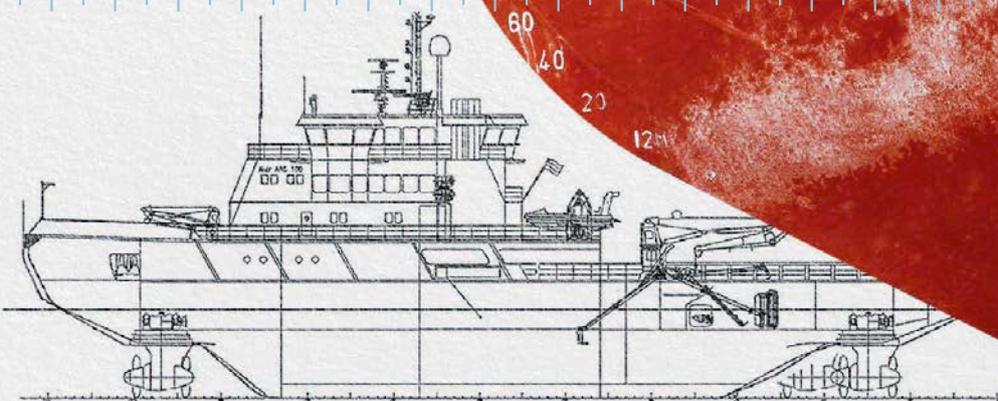
Even in the heyday of shipbuilding, Taizhou Kouan Shipbuilding Co. Ltd did not just focus on the three major mainstream ships — bulk carriers, oil tankers and containerships. It has retained part of the 'old business' of the company and continued to develop new ship types, such as engineering

ships and offshore auxiliary vessels, in order to open new opportunities. After the downturn of the market, the company has implemented the 'double adjustment' strategy for the product mix and market structure. At the same time as the continued development of the traditional main ships, the company has endeavoured to develop engineering ships, offshore auxiliary vessels, passenger ferries, fishing boats and other business ships so as to ensure effective business transformation and upgrade.

In summary, these shipbuilding enterprises have, among other initiatives, made use of market segmentation, undertaken adjustment of product mix, embarked on company transformation or conversion, diversified their business and developed personalised services to gain a competitive advantage. With the increased pace of merger and reorganisation in the industry and with competition akin to 'survival of the fittest', the Jiangsu shipbuilding industry will continue to compete in the high-end ship type field to build a brand for itself through innovation in research and development. **NA**



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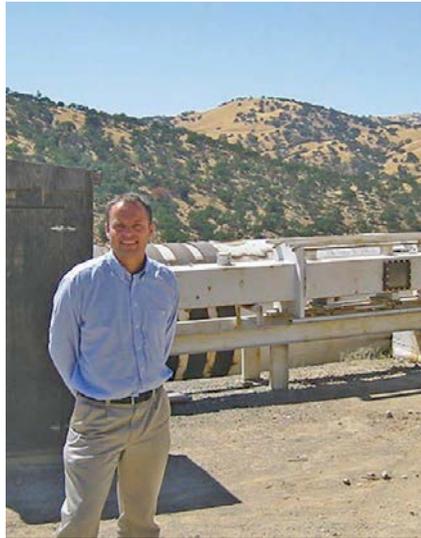
Hydrogen safety – some fuel for thought

Hydrogen's potential as a zero-emission marine fuel remains a work in progress, but what about the safety implications of this volatile element? *The Naval Architect* learns about the role CFD modelling plays in understanding the risks

Olav Roald Hansen, a senior principal consultant with Lloyd's Register (LR) based in Bergen, Norway, has been involved with R&D in explosion safety for 25 years. Hansen began his career in the oil and gas industry but following the 1998 oil crisis, and increased focus on greener alternatives, his attention turned towards hydrogen, in particular hydrogen consequence modelling using CFD. Hansen's work ultimately led to his involvement with the hydrogen expert group for the International Energy Agency (IEA), meeting safety experts from nuclear groups exploring the potential of hydrogen as fuel. Among the highlights of his work was training and interacting with researchers at the Sandia National Laboratories in the US in the use of FLACS (FLame ACceleration Simulator) software to complement large-scale experiments in hydrogen dispersion and explosion phenomena.

Hydrogen explosions, Hansen says, are both different, and in some respects more extreme, than those associated with natural gas and require complex calculations. "Hydrogen needs very little energy to ignite, 100 times less than a human static electric discharge (~1-2 mJ). So when it's released it can easily self-ignite. Hydrogen flames also require 100-1,000 times less energy than natural gas flames to transit from deflagration to detonation (DDT), a much more severe combustion mode with ignition by shockwaves ahead of the flame front, traveling much faster and at a higher pressure."

"With 3D modelling of such phenomena we're exploring the dispersion of flammable clouds, both the confinement pressure and also turbulence, either from the release itself or as the flame passes by obstructions, which accelerate the flames. These models have been benchmarked against experiments," says Hansen.



Olav Roald Hansen visiting the SRI-International CHES test site near Livermore in California where most large-scale explosion tests by US DoE/Sandia National Labs were performed in recent years

"When doing the risk assessment we use a combination of simple empirical relationship type models with more complex CFD when required. The art of such studies is knowing when to use the simple models and when to use the advanced approaches of CFD."

To be stored efficiently, hydrogen needs to be cooled to liquid (-253°C) or compressed at high pressure. One challenging safety aspect related to liquid hydrogen is that the gas cloud from a release may be denser than air, and air may also condense or freeze close to the release. 350 bar (5,000 psi) and 700 bar (10,000 psi) storage are the standard for hydrogen tanks in cars. But the molecules are so small compared to air that they slowly escape (permeate) from containers of most materials. Certain steel qualities may then become porous, crack and ultimately develop leaks. A high-pressure tank that is punctured may explode and

generate shockwaves. Such scenarios are very unlikely, and their assessment, combined with more frequent, less severe leak and explosion or fire events, may require a probabilistic approach to establish safe distances for personnel or third parties and also minimise the risk to structural integrity.

Flame speed for hydrogen at optimal concentration (30%) is several times higher than for methane and explosion overpressures often 10-100 times higher. If concentrations can be kept below 10-15%, hydrogen explosions will be less severe than methane explosions. For design it is imperative that storage tanks are located such that the volume potentially released within a confined space is limited or such that the gas quickly disappears by buoyancy. Ship design must therefore factor in the hydrogen inventory and maximum leak rate versus compartment size and ventilation.

Because hydrogen explosions are such rapid phenomena, it often makes little difference for consequence studies whether the affected structure is moving, Hansen says, although the additional strains and impacts from a marine environment can increase the likelihood of equipment failure relative to a stationary situation. He adds that while the shipowners he encounters are conscious of the importance of safety, they are increasingly open-minded to the potential of hydrogen, albeit some may still be wary of investing even in subsidised projects.

Irrespective of safety, until such a time as there is large-scale hydrogen production e.g. at major refineries (with carbon sequestration) there will remain concerns about cost and availability, he believes. Moreover, the low energy density of hydrogen storage (requiring larger volumes, albeit at a lower mass) and likely less efficient global transnational

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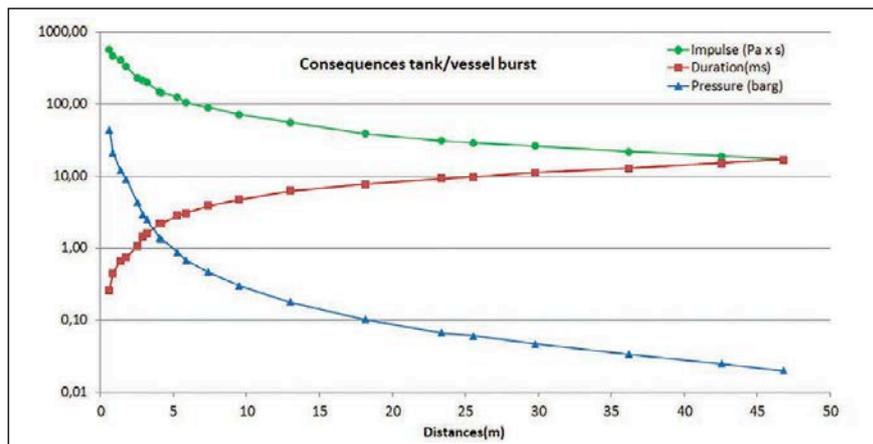
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incentives (compared to national incentives to limit local pollution and noise) it is still debatable if hydrogen will be a practical and popular fuel for deep-sea vessels.

Norway has a long heritage in hydrogen usage. In 1929, the world's then largest hydrogen plant was opened as part of a Norsk Hydro fertiliser facility. Today, research into its fuel potential, both for maritime and automotive, continues at pace, with the country's re-elected prime minister, Erna Solberg, explicitly referencing hydrogen research and demonstration projects among green initiatives during recent campaigning. Hansen says that LR Norway is currently being consulted in the building of several hydrogen car refuelling stations, as well as a solar cell-based hydrogen production and refuelling facility for trucks.

Hydrogen is just one facet among numerous electric ferry concepts in western Norway at various stages of development as the country strives to achieve zero emissions. One of particular interest is the Mobility Zero Emission Energy Systems (MoZEEs) initiative. LR is among several partners in a five-year



LR screening tool for a tank explosion

project being led by the Institute for Energy Technology to develop, test, validate and study performance of battery and hydrogen fuel cell technologies. "One of the things we are doing is to develop risk-assessment approaches for such systems and also support the ongoing development of a high speed passenger boat concept," says Hansen.

LR is also looking at what it takes to class a ship with hydrogen as fuel. Hansen explains: "Because there are

few standards for hydrogen we have to develop an alternative risk-based approach. The start phase will be to class vessels based on the requirements of the current low-flashpoint fuel code (IMO's IGF Code) and then consider key specifics for hydrogen. You don't follow the deterministic standards word for word but follow the intention and adjust it accordingly. At least those are the initial indications we're getting from the Norwegian shipping authorities." **NA**

Pragmatic design keeps polar vessels safe

Growing demand for polar cruises is leading to a boom in new projects, but owners and designers alike risk putting form before function, Foreship's chairman tells *The Naval Architect*

After years of deliberation at IMO, the International Code for Ships Operating in Polar Waters (Polar Code) finally entered into force on 1 January 2017. The Polar Code sets down binding regulation for navigation in the Arctic and Antarctic, covering everything from which equipment should be carried to environmental protection measures.

In terms of the design and construction of vessels, it specifies the operational parameters of vessels, the provision that should be made for their stability subject to ice accretion or damage, their structure and materials. But the goal-based framework of the Code has drawn criticism that safety



requirements are somewhat ambiguous or don't go far enough.

Foreship, the Finnish naval architect and engineering company, is well positioned to give a designer's perspective on the Code's efficacy. Foreship provides concept designs and consultancy services for shipowners and yards and so has been engaged in a number of purpose-built polar passenger ship projects, notably the *Crystal Endeavour* (a 1,000 passenger ice-strengthened luxury ship under construction in Germany) and *Scenic Eclipse* (a 288 passenger 'discovery yacht'

Markus Aarnio

that will be built to Polar Class 6 and operate in both the Arctic and Antarctic).

Markus Aarnio, chairman at Foreship, says it's an exciting time: "All the earlier expedition ships were really old, mainly old ferries that had been converted. But now is the first time there are so many projects specifically built as expedition ships."

But Aarnio says there remains confusion concerning the difference between vessels that have been categorised as fit for operating in the polar regions and those polar notations determined by the classification societies. "The simple way to look at it is if you want to go to the polar areas, that's north or south of 60°, then the ship has to be Polar Code compliant. However, that doesn't necessarily mean it needs to be of polar class. If you want to go to Greenland then you need Polar Code, but for Iceland or the Baltic you needn't.

"Let's assume it's Greenland. You have to decide whether your ship will meet Polar Code A, B or C. 'A' is basically for icebreakers, not really for cruiseships, but if the owner wants something really extreme. 'B' is capable of handling thin first-year ice — to meet that then you will need a polar class notation of 6 or 7. But most of the polar exploration vessels are Polar Code C and you don't need ice class — you can have something like 1C, 1B or 1A [the notations for vessels operating in sub-Arctic waters]."

In other words, older vessels, or those which only make occasional incursions into polar areas, are perfectly comfortable with Code C. However, while in theory 'B' is the stricter standard, Aarnio says in practice it has little bearing on design. The Polar Code is a goal-based regulation, meaning that the vessel's operational profile will define the requirements placed upon it.

"Goal-based regulation is a bit more difficult to work with but I like it more," reflects Aarnio. "If you have a research ship then you would operate there all year round, but a cruiseship would only operate in the summer when there's little ice and mild temperatures."

However, there are many misconceptions among shipowners about what is now permissible, or at least



Concept drawing for *Crystal Endeavour*. Foreship is designing the 160m polar cruise ship for MV Werften, the first in a series of 'Endeavour class' expedition ships that will be built for Crystal Cruises

sensible. "Many think that now there is Polar Code they can go to the North Pole, but of course that means breaking through 2m [of ice] and you'd need some kind of nuclear icebreaker. There are some cruiseship projects you see now where they've designed the ship so it's an icebreaker hullform with a sloped bow so that the ship goes forward and crunches the ice downwards. But it's not good for wave making and most of the year you will be in open water and use huge amounts of fuel for nothing.

"I would say a Polar Code cruiseship can be more like an ice-class Baltic ferry, where it has an open water hullform with a bulbous bow but it can still break ice. Then there's the vertical bow that many naval architects seem to like nowadays which is quite good in the open water but can get wedged in the ice."

Polar Code affects stability in two ways: ice accretion (applicable to all categories of vessels) and damaged conditions (relevant to both Code 'A' and 'B', but particularly the less robust requirements of the latter). In the case of damages, ships constructed after 1 January 2017 are expected to be able to withstand flooding due to hull penetration from an ice impact, however older vessels are likely to be challenged by the smaller stability margins.

Another requirement of Polar Code is the provision made for life saving

appliances and how it should be interpreted. Chapter 8 of the Code specifies: "All life-saving appliances and associated equipment shall provide safe evacuation and be functional under the possible adverse environmental conditions during the maximum expected time of rescue." However, it is left to operational assessment to determine whether this means special lifeboats are designed to withstand polar region conditions, how much additional heating and clothing provision needs to be included onboard the lifeboats, whether it means the vessel should carry less passengers or crew or even whether it might be necessary to abandon the vessel and disembark onto ice.

But there's a difference between a vessel being well prepared and overkill. Aarnio adds that when it comes to Polar Code some designers are showing a tendency towards forgetting good shipbuilding practices. In the Antarctic, a 500-passenger capacity applies (to landing), meaning there needs to be greater pragmatism. "If you go to the South Pole, where you can have really bad weather, is it really clever to have a balcony close to the window or a window at the front of a ship? Of course this is nice [for the passengers] but at some stage you will face a really big wave and those windows will break." **NA**

Virtue and function

Energy saving devices are key to meeting new emissions imperatives, but they can sometimes add complication and unforeseen design challenges. Dr Hanshin Seol, Korea Research Institute of Ships and Ocean Engineering (KRISO), shares a practical approach to ESD design and two new developments

A large number of energy saving devices (ESDs) have been developed and applied to ships, but only a few have been successfully utilised because of structural and economic problems, according to Dr Hanshin Seol, KRISO.

“Recently, side effects caused by energy saving devices have been frequently reported, which is a full scale performance issue including maintenance and structural problems, like propeller erosion,” says Seol.

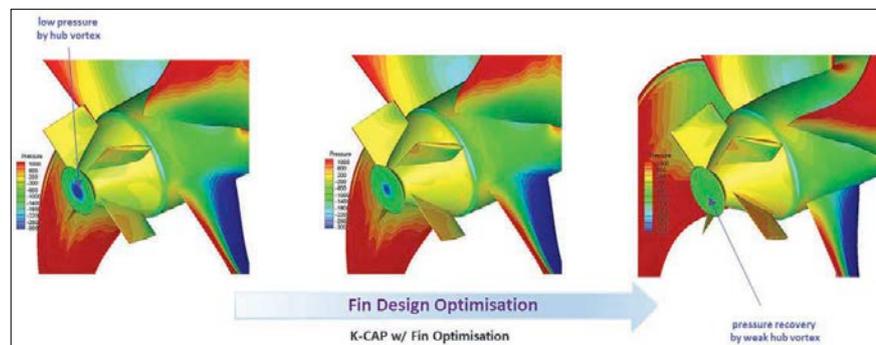
“Some ESDs, especially those that increase propeller loading like duct and stator type ESDs, show good propulsion efficiency improvement in model tests, but sometimes [these results] do not represent their performance at full scale. Therefore, the effects of these types of ESDs are still controversial due to the scale effect — because the inflow wake is much different at model and full scales — and these types of ESDs tend to over-predict their real performance in model tests.

“Furthermore, these types of ESD can also cause structural problems. Recent results show that the propeller design to achieve high efficiency and the energy saving device are basically designed to increase the load of the propeller. As a result, the cavitation behaviour of the propeller becomes bigger or more violent, which can cause adverse effects like hull vibration. Even propeller erosion phenomena has been reported due to the abnormal flow caused by an ESD.”

In search of an answer

In response, KRISO began a research programme in 2014 to develop technologies to improve ship propulsion efficiency and to reduce the radiated noise of the ship propeller by improving the cavitation phenomena occurring around it.

“We went in with the idea to secure the rotation margin so not to overload the engine, to have as little an impact on the structure as possible — avoiding pitfalls such as propeller erosion — and to ensure the economic viability of the technologies we developed,”



explains Seol, who led the project. This involved considering both wake improvement devices that would sit in front of the propeller and appendages placed behind the propeller, and centred on the idea that the developed technology would both be easily applied to new and existing vessels and be cost effective.

A preliminary study on representative fin techniques to improve propeller cavitation characteristics was conducted early on in the institution’s research, but in order to develop a device that satisfied both cavitation characteristics and propulsion efficiency the design team started to study the design of vortex generators and propeller caps, which it believed could be installed easily and cheaply.

Following three years of research, two types of ESD — an energy saving hybrid cap called K-CAP and an energy saving vortex generator called K-VG (KRISO Vortex Generator) — have emerged from the work conducted.

K-CAP is a departure from existing types of propeller caps. Generally, in the case of convergent type caps, the rotational flow generated from the propeller blades is gathered and strong rotational flow is generated behind the cap. In the case of divergent caps, the rotational flow caused is scattered, weakening hub vortex flow, but also decreasing propulsion efficiency — resistance is increased due to the shape of the cap.

K-CAP, however, takes advantage of both convergent and divergent shapes,

simultaneously minimising cap resistance and weakening hub vortex flow. It effectively works as a new hybrid propeller cap that can control propeller hub vortex cavitation, and in doing so, improves propulsion efficiency, according to Seol.

In addition, an elaborately designed fin was created and paired with the cap in order to maximise propulsion efficiency and recover rotational flow energy that would otherwise be lost. “The K-CAP is considered to be effective for ships with large propeller loads due to the characteristics of recovering the rotational flow behind a propeller. Therefore, high speed containerships, passenger ships, LNG carriers and warships would be suitable adopters,” notes Seol.

“The K-CAP showed a 1-2% improvement in propulsion efficiency in the model test. Considering the model full-scale ship performance correlation study of existing propeller caps and the results of an International Towing Tank Conference (ITTC) study, the developed K-CAP is expected to improve the propulsion efficiency by more than 3% for full-scale ships.”

Wake improvement

The second technology, the K-VG, acts as a wake improvement device, improving propulsion performance by 2-5% and reducing hull pressure fluctuation by 30-40%,

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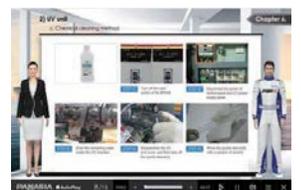
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- a) IMO BWMC Guidelines are specific, requiring training on the operation and maintenance of installed ballast water treatment systems and on the safety aspects associated with the particular systems and procedures used on board the ship.
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according to KRISO studies of the technology for VLCC and tanker vessel types.

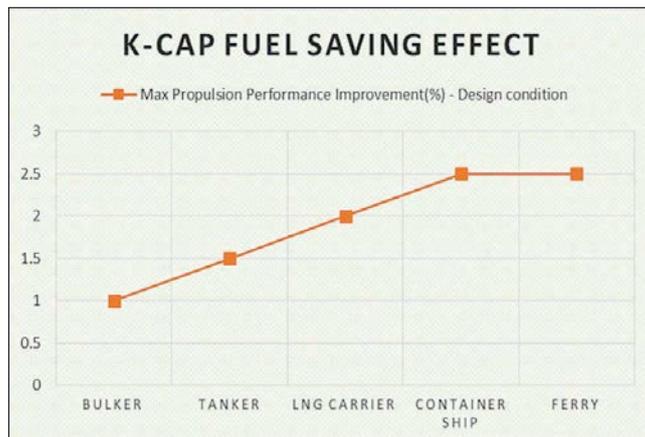
It attaches to the hull in front of the propeller, generating a strong vortex that delays the flow separation at the stern region of the ship, reducing ship resistance.

Vortex generators have been shown to cause propulsion efficiency losses in some cases, explains Seol, so KRISO borrowed design techniques used in the aero and auto industries where vortex generators are used as high lift and fuel-saving devices. The device subsequently accelerates the slow flow into the ship propeller, improving cavitation characteristics for the vessel. As a result, propeller inflow and thus the wake are improved. The ship's noise and hull characteristics are also improved and the propeller erosion phenomenon is diminished.

Seol emphasises that K-VG, unlike other ESDs, has the ability to improve propeller cavitation behaviour and propulsion performance at the same time, providing performance and eco-friendly credentials through the diminution of underwater noise radiation.

During the early stages of research and development, inconsistency with model test results occurred due to incomplete numerical simulation for ESDs of this design technique, according to Seol. Consequently, in

Calculated savings with K-CAP by vessel type



order to mitigate this problem, various verification studies were conducted during the development of the K-VG and K-CAP. This involved analysing the correlation of physical phenomena that might occur in numerical simulation and model tests.

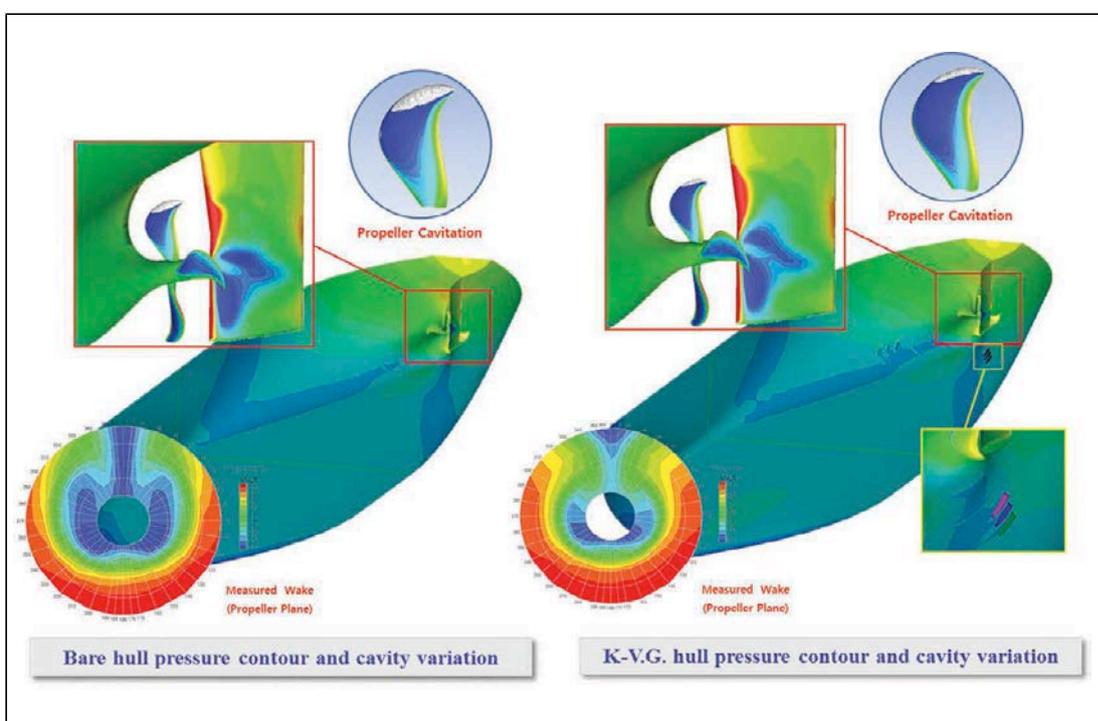
An ongoing design challenge lies in striking a functional compromise. Depending on the type of vessel to deploy the technologies, there can sometimes be a conflict between the two objectives laid out above (to improve propulsion and improve propeller cavitation characteristics) when arriving at the optimum K-VG and K-CAP design for the vessel in question. As a result, the target is set according to the performance

of the ship and the demand of the customer, says Seol.

Looking forward, Seol reveals: "We are currently working on a number of full scale application projects in cooperation with shipyards and shipping companies...[and] in the near future we will verify the performance and effectiveness of the ESD's through a full scale test."

Research is already underway to address the impact of propeller erosion by the developed ESDs, and, on the basis of these studies, it is planned that these advanced ESDs will be applied to ships which have propeller erosion or vibration problems due to propeller cavitation, concludes Seol. *NA*

The K-VG is a wake improvement device



NAPA partnership is big news for computer-aided ship design

Collaboration between NAPA and other software providers, starting with NDES, could provide the key to streamlining the ship design process

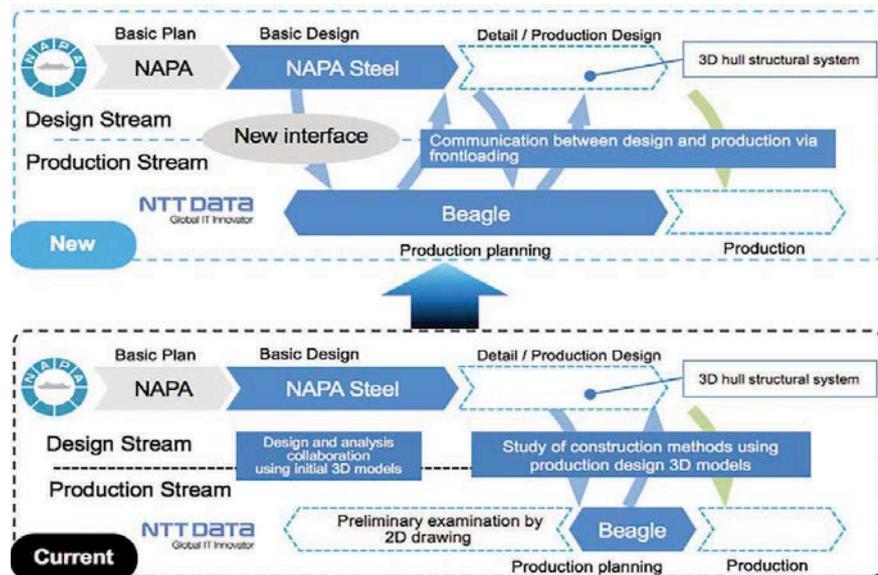
Last issue, *The Naval Architect* touched upon the news of plans for a collaboration between maritime software leader, NAPA, and Japanese software development and engineering experts, NTT Data Engineering Systems (NDES). The project aims to significantly reduce costs associated with the design and production of ships, by improving compatibility between the companies' respective software programmes.

NAPA's software, NAPA Steel, is currently used by shipyards and ship designers in the structural design of vessels. By utilising a 3D model from the very start of the design process, it has proved a popular choice with companies around the world for its enhanced accuracy and ability to increase productivity.

NDES' offering, Beagle, which has a large user base in Japan, is a 3D ship structure viewing software that is used for production planning and design review, focussing on areas such as assembly sequence study, painting and welding length calculation per production stage.

Both companies aim to link the two software programmes so that 3D design data created in NAPA Steel can be used to create visualisations in Beagle, therefore presenting the opportunity to review production plans in the early stages of design rather than later in the design process, as is currently common practice. At present, users are able to study production in Beagle with data created using 3D-CAD tools, but this is only possible once the proposed project has reached the production design stage.

As well as aiding the initial design process, it is hoped that any material purchasing and manufacturing considerations will be taken into account much sooner than current methods facilitate. Tapio Hulkkonen, development director, NAPA Design Solutions explains: "Using early 3D models in production planning allows earlier access to accurate information



Users will be able to create visualisations in NDES' Beagle software using 3D design data created in NAPA Steel

for the material purchasing process. With more time then available for the purchasing process, it will be possible to reach more suppliers and thereby increase the chances of finding better quality solutions. At the same time, this speeds up the overall design and review process by giving production reviewers faster access to 3D models. This then reduces the overall total cost of ship design and manufacture."

Speaking with *The Naval Architect*, Hulkkonen elaborates on the most significant benefits ship designers and yards could see from this collaboration: "The main benefit here is that this allows earlier, closer collaboration between early stage design and the production planning and review processes.

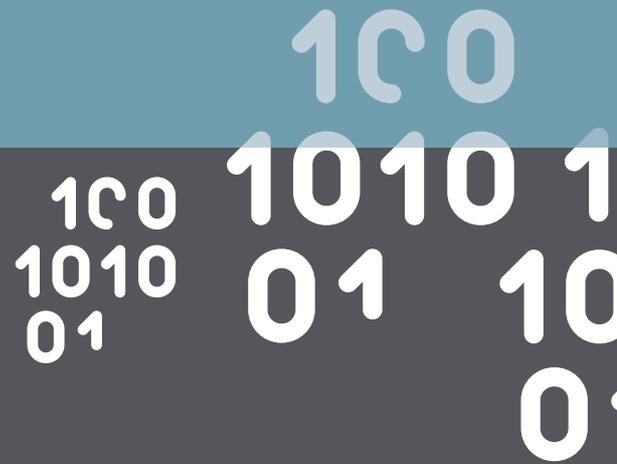
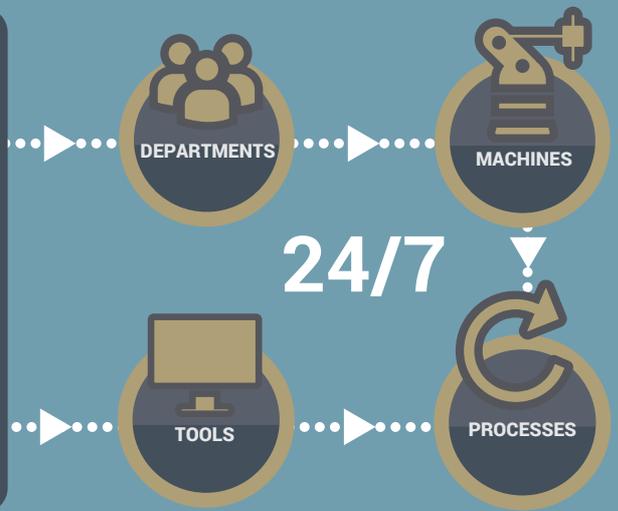
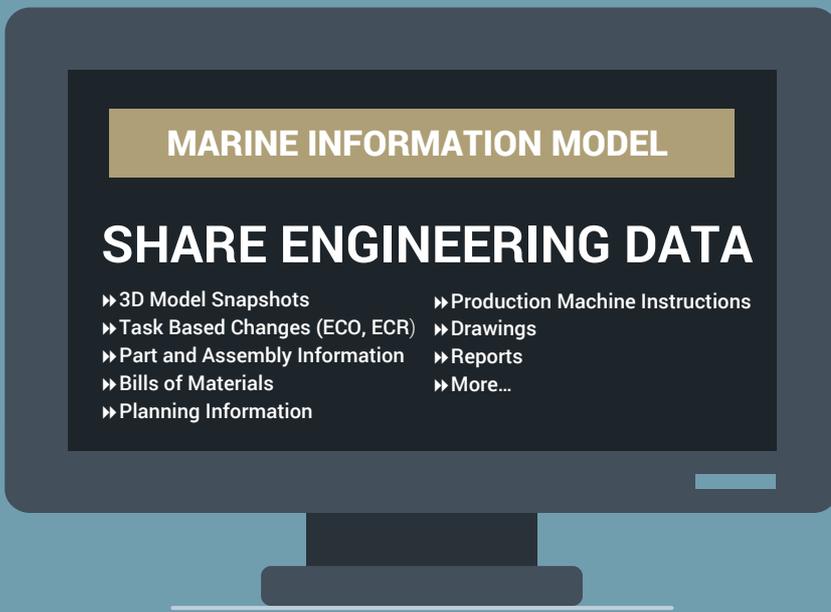
"During the early stage design process, production review has been only possible using 2D drawings. Separate production design 3D models have traditionally only been created during later design phases for manufacturing purposes — the same models that are used for

production planning purposes. Because of the late introduction of these models, review at the initial stages has been time consuming and difficult.

"With NAPA's early 3D models accessible in NDES Beagle, it will be possible for production planners and reviewers to easily extract all the needed information quickly and reliably during early design phases."

The project is still in its infancy, with technical development taking place to create the core level functions to make the merger possible, according to NAPA. Hulkkonen continues: "Testing and trials have so far been concentrating on API level functionality. The end user testing will follow later and it will be committed with some pilot customers in Japan."

Rather than creating a single integrated platform, NAPA wants to "ensure that the latest 3D ship design technology can be leveraged as widely as possible" and so will continue to develop similar interfaces with other software providers, Hulkkonen concludes. **NA**



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Virtual reality empowered design

Alfonso Cebollero and Luis Sánchez of SENER, Spain, discuss the logistics of integrating virtual reality into shipbuilding and design and what it could mean for the future of naval architecture

In much the same way as other advanced technologies in the past, virtual reality (VR) has, until recently, only been used in a few professional environments due to its relatively high cost. Remarkably, in engineering projects where the final product is available as a digital mock-up allowing immersive interaction, VR has already shown its potential for design review, ergonomics and usability studies and simulation of assembly operations, among other practical applications.

At present, the increasing availability of affordable VR gear and portable devices is favouring the development of new solutions in many more fields of application, including home entertainment, which will let us interact with the virtual world like never before.

So how are these new ways of man-computer interaction being translated into the shipbuilding business? In particular, how are computer-aided design and manufacturing systems incorporating VR technology? And how will the new generation of naval architects and marine engineers design?

Virtual reality (VR), which we can define as “a computer-generated digital environment that can be experienced and interacted with as if that environment were real” [1], is rapidly consolidating in response to the industry demand. It is no longer just about having 3D visualisation, moving objects or querying their properties. Now, those objects are expected to have the same behaviour as they would have in the real world, and immersive systems with much more advanced interfaces and a more natural interaction are required.

VR solutions and configurations

There are different VR solutions available in the market which are especially suitable for the shipbuilding industry. The



A powerwall-based Virtual Design Centre, provided by SENER, at Navantia Cartagena (image courtesy of Navantia)



CAVE (image courtesy of ESI Group)

decision on which one to implement is not easy, as they require specific hardware components that are in a constant process of improvement and there are a series of factors that may influence the choice, such as space, budget and intended use.

The simplest and often only viable way to easily and quickly create a practical VR environment is to have a transportable, self-contained system. Basically, this consists of a stereoscopic projector with a wide angle lens, a portable tracking system and a laptop

computer, all packed in a suitcase, and a screen with foldable aluminium frame. When bright ambient light is a problem, a wide-screen 3D television may replace the screen and projector.

If the purpose is to set up a VR-specific room, there are several large format options. A good compromise between cost and performance is the high-resolution display wall or ‘powerwall’. Typically, a powerwall features a 4m-plus screen and a rear projector to avoid shadows. In front of the screen, the working area is limited by the scope of the tracking system. These large flat screen systems allow a wide field of vision, which provides an excellent feel of immersion and interaction with the full-scale 3D objects shown.

With more space and budget, there are many more possible options including the Cave Automatic Virtual Environment (CAVE). The CAVE consists of four, five or even six projection faces (typically to the front, left and right of the viewer, plus one on the floor, sometimes also on the ceiling and to the back) and delivers the greatest feeling of immersion. Several

persons can stand and walk freely between the screens and are immersed in the 3D world being displayed.

Hardware components

The VR simulators require a series of hardware components, the most important being stereoscopic visualisation systems, tracking systems and computer systems. Usually they also include hi-fi audio systems, control systems and specific supports. The perfect integration of these systems is what creates the artificial reality where the participants can interact with objects in an immersive mode.

Visualisation system

The visualisation systems used in one-face solutions, like powerwalls, and multiple-face solutions, like CAVEs, consist of three main elements: screen, stereoscopic 3D projector and glasses. Front projection screens reflect the light, meaning the surface must therefore be highly reflective, so that the audience captures the image as perfectly as possible. Rear projection screens diffuse the light through the material. The surface must transmit an image with true optical clarity and brightness, making it necessary to use a source of higher intensity with rear projection.

There are two types of stereoscopic projection: active and passive. In both, the 3D effect is achieved by 'deceiving' the sight through the use of special glasses which cause the right and left eyes to see a different image. In terms of projection technology, there are three choices: LCD, LCoS or DLP. In addition, DLP has two varieties: one-chip (with colour wheel) and three-chip (one chip for each primary colour). The three-chip DLP technology is widely regarded as the most advanced solution in terms of image quality. However, for many applications it's sufficient to use single-chip DLP or LCD technologies, which within the same price range, offer similar quality and performance, with a slight advantage for DLP in VR-related applications, as DLP projectors tend to be brighter than LCDs.

The type of glasses needed depends on the type of stereoscopic projection, passive or active. In the passive stereo, special glasses filter by polarised light direction (orthogonal polarising directions for left/right eyes) or by colour (different colour — red/green or red/blue — for left/right eyes). An example of passive projection is large-screen

projection systems. There are also two types of active stereo projection. One is based on image separation by location —each image is channeled to the respective eye by a separate optical system an example being head-mounted displays (HMDs). The second type is based on separation by time and relies on both images being separated in a rapidly alternating sequence. Examples are CAVE, monitor-based VR and certain large-screen projection systems.

Tracking system

The ability to add a motion tracking system (MTS) is the most effective way to improve interaction with complex 3D objects or datasets in an immersive environment. Usually motion capture sensors are placed on the head (attached to the glasses) and the wands for the hands.

There are several tracking technologies. One of the most frequently used is optical technology (visual tracking). Active or passive marks are fixed to the subject to be followed and their position is stored. Passive marks are illuminated by radiation sources (infrared or ultrasound) and the rays are reflected towards a detector. Active marks emit rays into the detector by themselves.

For electromagnetic tracking, a stationary transmitter creates electromagnetic fields, within which

moving receivers or sensors register an object's position and orientation.

Mechanical tracking uses a direct mechanical connection between the object to be tracked and a reference point, such as a mechanical arm with rotating joints that allow for six-degrees-of-freedom control.

Ultrasonic tracking utilises three or more stationary microphones that receive an acoustic signal from a moving emitter. The differences in signal time delay and triangulation yield tracking data.

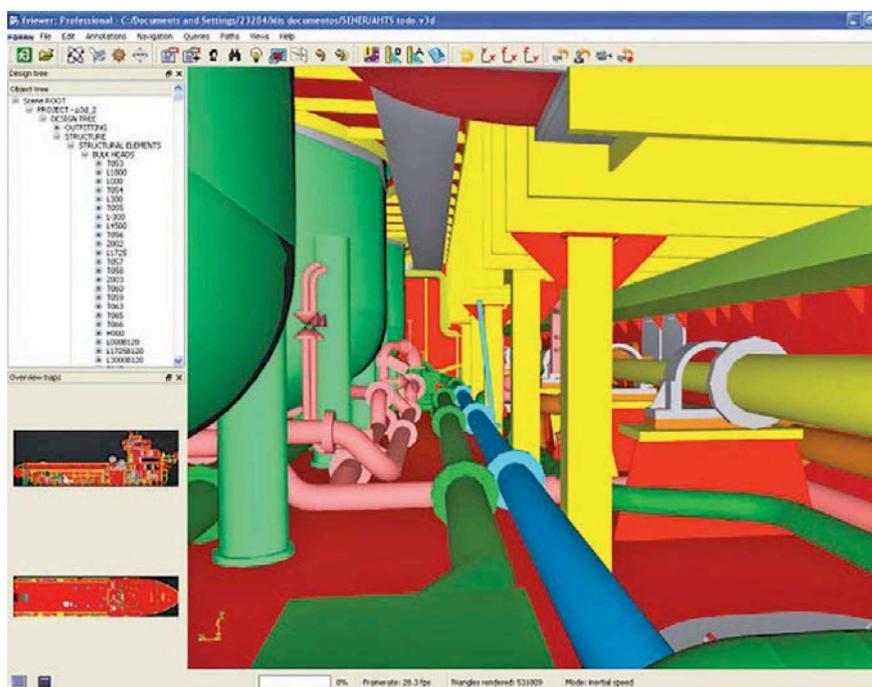
Lastly, the inertial tracking system uses a couple of miniature gyroscopic sensors to measure yaw, pitch and roll. They measure only orientation, but they can be effective as head-tracking sensors where position information is not essential.

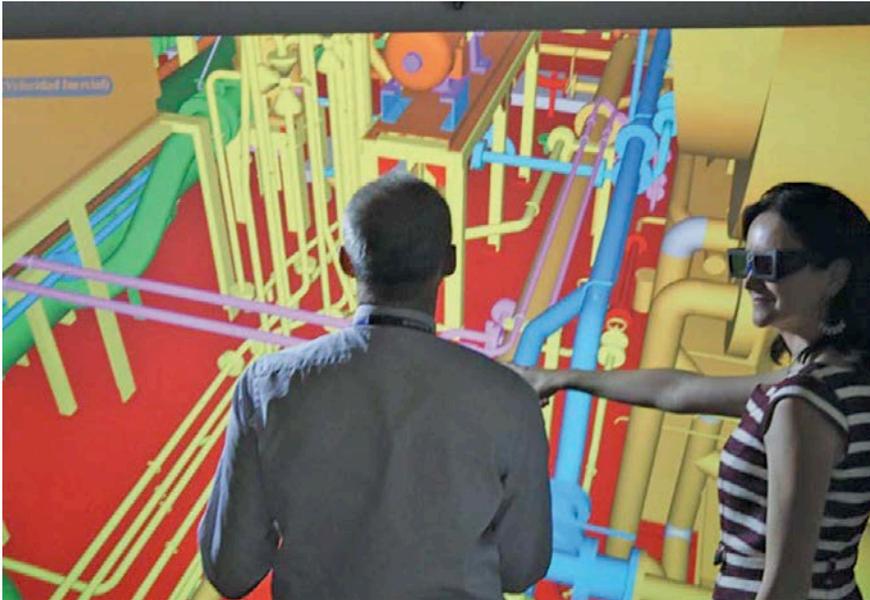
In order to manage the vast quantity of information contained in 3D ship models, a powerful computer system, tailored to get the most out of processors, memory, graphics cards and software, is indispensable.

Foran software

Foran is a computer system specifically developed for the design and construction of all types of ship. It has been developed, marketed and maintained by SENER for more than 50 years.

Screenshot of FViewer module





A VR-supported design review with Foran

From the outset of VR technology, SENER incorporated it into Foran through its own and fully integrated development. Around the end of the 1990s, the Visual3D module for walk-through design review already featured two of the necessary characteristics for creating VR: immersive navigation and stereoscopy. Contrary to the rest of the modules of the system, this program did not read the information from the database, but from proprietary format files, which brought advantages such as faster reading, simplified geometry and smooth navigation through and around large models.

In the launching of the version 80 of Foran, in 2012, the FViewer module superseded Visual3D. The new module was developed for a 64-bit platform, which allowed the use of much more RAM and therefore the possibility to navigate throughout large 3D models with fluidity and ease, even when the stereoscopy is activated.

Like its predecessor, special 3D files were used to load the information in order to get acceptable performance in the rendering of the scene of a whole ship. Some of its features include:

- Simulation of assembly/disassembly of equipment
- Incorporation of light points and textures
- Multiple camera positions

- Creation of screenshots and videos at 4K resolution
- Connection to HMD devices

Taking the implementation of VR technology one step further, SENER and ESI Group, a leading simulation software company, have teamed up to provide the most advanced solutions for the shipbuilding industry by perfectly integrating Foran with IC.IDO.

IC.IDO is a powerful VR solution by ESI Group that combines high-end visualisation and real-time simulation of product behaviour in its actual size, and allows product operation very close to reality. It offers an excellent compromise between performance, working efficiency, visualisation quality, real time physical simulation of dynamic components and real time user interaction.

The integration of Foran with IC.IDO adds some advance features to the ones mentioned for FViewer, including:

- Advanced ergonomics with virtual humans (in any position with total freedom of movements and field of vision)
- Point cloud management
- Data import from different CAD sources
- Physics simulation (collision, friction, gliding, flexibility, kinematics etc.)
- Multi-channel support (optimised for complex CAVEs or rooms with multiple

projection screens)

- Multi-site collaboration

VR applications in shipbuilding

VR is one of the technologies that has the greatest future for engineering and manufacturing, since it can be used to improve the design and planning in an interactive collaborative environment, providing an unprecedented understanding of the product in a complete 3D immersion.

VR can be used in different phases of the ship project, from the initial stages of engineering to the maintenance phase when the ship is in service.

A constant review of the engineering can avoid unnecessary development costs and delays in the production phase. Designers may make mistakes that can easily be identified in a virtual validation process. The VR allows, in a much easier way than with a classic 3D CAD environment, to locate faults in the model. In addition, VR users can attach annotations related to problematic elements and share them with designers.

Another important application of VR is the validation of the production information, since any problem not detected will have an impact on the construction cost and schedule. Virtual manufacturing allows the shipyard to assess if the design can be built and likewise help to define the best sequence of assembly operation.

On the other hand, having a tool that allows simulation of any manufacturing task can help to efficiently train the operators who will execute it and produce documentation, either images or videos, of the whole process.

Once the ship is delivered, regular maintenance should be scheduled. All service and maintenance operations can be simulated in the immersive system. The goal is not only to learn and practise these operations, but also to optimise them. There are situations in which the crew must make repairs in difficult situations and the optimal training can help. As a complement, creating 3D documentation as videos can help facilitate the work of operators and in many cases overcome barriers, such as language.

During and after the development of the project it is necessary to present

it to customers, suppliers and other ship-owners. In this regard, VR is a very effective sales and marketing tool.

New devices

For years, the use of head-mounted displays (HMDs) has been reserved to the business world due to their high cost. Segments such as military or aerospace have been the first to adopt this type of device in different programmes, but the picture has changed radically and now there are affordable VR gear and amazing portable devices that allow us to interact with the virtual world in an unprecedented way.

Portable devices are embracing VR — from attachments for smartphones that allow users to experience stereoscopic visualisation with certain apps, to 3D glasses equipped with displays that provide us with a feeling of immersion very similar to what we would experience in a sophisticated CAVE. Some of these portable devices currently meet the requirements of VR for shipbuilding with acceptable performance, in other words, with graphic processing capable of handling the heavy 3D models of a ship. Good examples are Oculus Rift or HTC Vive.

These devices, comfortable and light, offer the possibility of using motion tracking controls as an extension of our body, including different sensors like accelerometers and gyroscopes.

Plus, the manufacturers supply software development kits (SDK) for third parties, for instance CAD programmers, to develop applications built upon a powerful and complete rendering kernel, that exploit the full capabilities of the new devices.

When developing said applications some fundamental aspects must be considered:

- The design of the motion system within the scene cannot follow the conventional rules, as special care must be taken not to cause excessive dizziness in the user.
- The ability to interact with nearby objects in a more natural and flexible way requires higher quality in textures.
- The interaction with the environment is different: not only through the use of pads, but also by hands tracking.
- The high resolution of the screens (usually 2169x1200) requires graphic

processing capability to achieve from 60-90 frames per second.

Rendering, image ratio, working resolution, head-tracking operation, point-of-view control, position tracking, scene acceleration control, motion speed, camera position, stereoscopy settings and user interface are just some of the aspects that software developers must be aware of to obtain the desired result in the immersive experience.

It is not easy, however, to develop a valid application compatible with different devices. That is why the Open Source Virtual Reality (OSVR) project, which aims to enable all headsets and game controllers to work with all games, presents an open SDK to create universal content for VR that can be targeted by device manufacturers as well as the open development community. The adoption of this SDK by all manufacturers would in the future allow the compatibility of third-party software with a wide variety of glasses and new VR devices that may appear in the market, with few modifications at the code level.

The future of shipbuilding CAD

In the industry in general, and the shipbuilding field in particular, most VR tools have their application when a 3D product model is available. For uses such as analysis of the production information or operator training, their application is possible as the 3D information is practically the final version, given the design maturity.

As previously mentioned, the main applications of VR in ship design and engineering are the review of the model aimed at identifying errors and the evaluation of alternatives. This review-and-modification process is realised mainly in projects where there are complex zones, such as the engine room of a ship or a cramped submarine, and it is necessary to iteratively refine the 3D model, moving from the CAD workstation to the VR simulator successively until the project is validated. This process is costly, as it involves generating the 3D models, transferring them to the VR software and reviewing them with some additional information.

The immersive environment, with the designer ‘inside’ the scene, permits much better understanding of the space in a much more natural way. Being able to act directly over the 3D model and make the necessary changes would save time, especially in those projects of high complexity.

Some typical tasks for which this new way of working would be really feasible are: equipment layout (positioning and displacing items and even affecting surrounding elements), routing of pipes, cable trays and HVAC ducts, insertion of fittings, definition of supports and other outfitting structures.

Having a CAD system that allows for modifying elements directly within an immersive environment would also be very useful in collaborative sessions in a powerwall room or a CAVE where different engineers make decisions. The possibility to make the changes in real time can result in significant time and cost savings.

Another field of application is production organisation. The 3D model is created according to design criteria, but it must also be organised into a product structure based on a build strategy, that is, a breakdown of elements adapted to the different production units. The assignment of objects to the different units could be done easily and intuitively within the virtual scene. This would be applicable to structural assemblies as well as to pipe piece fabrication and mounting.

In the future, it is hoped that CAD systems will evolve in order to ensure that VR technology is used directly whenever necessary or convenient. Thus a new future would open to designers, who could place themselves inside the scene and create or modify elements in a way never experienced before.

The incorporation into ship design of CAD tools compatible with VR devices would allow designers to use VR more generally and at a lesser cost, shortening the overall design-review-modification process.

For a CAD system to allow working in an immersive environment, it must evolve in the following aspects:

- Graphics engine: modelling tools must include advanced graphics and

rendering engines that allow a fluid immersive navigation with stereoscopy as well as compatibility with VR gear.

- Performance and massive use of data: the system should be prepared for handling huge volumes of information, which may be stored in a database and must be loaded dynamically in the scene during the working session.
- User Interface: the monitor has been replaced with VR glasses; the mouse, with handheld devices such as wands or joysticks. The designer cannot see the traditional keyboard. The interface in traditional CAD does not serve anymore and the commands must be invoked in a very different way (voice, gestures etc).

SENER software engineers are now working on the development of a new, modern graphics engine, the heart of Foran. This involves not only a visual

change, with photorealistic rendering, stunning animations and new visualisation modes (shadows, cell rendering, point clouds, textures, stereoscopy), but above all, a functional change to endow the system with new features (object handlers, interactive 2D/3D handling, walk-through navigation mode) to fully exploit the potential of all the different graphics cards currently available and to connect the visualisation system to new technologies such as CAVEs and HMD devices. **NA**

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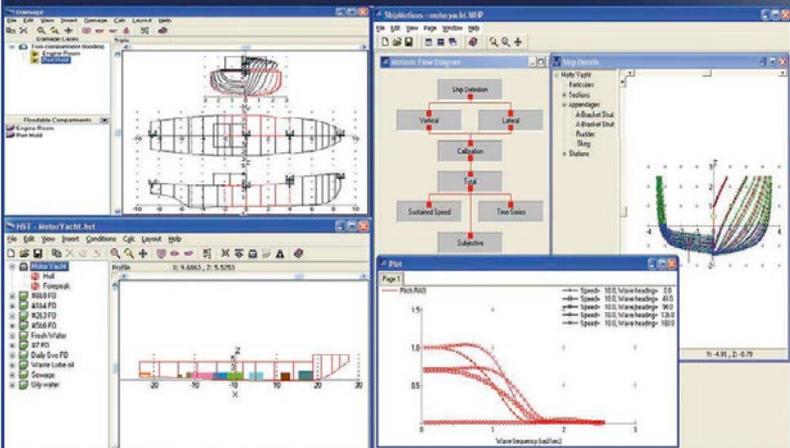
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The need for (understanding) speed

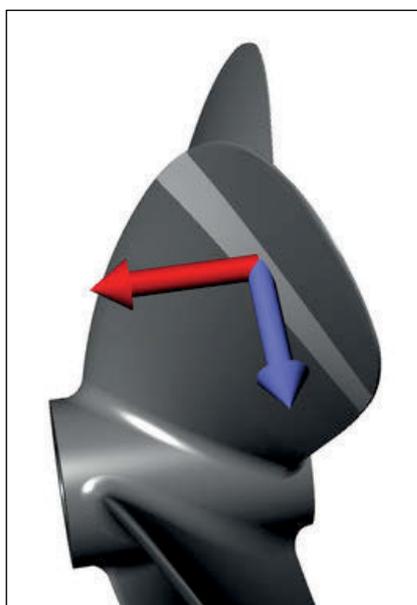
To what level of detail should naval architects be evaluating propeller performance? Donald MacPherson, technical director of HydroComp Inc, puts the case for more active engagement

When it comes to the design of many vessels, naval architects are selling speed... or so one would think. Actually, they are selling speed 'with conditions'. Those conditions are many, but a few of the major objectives and constraints are to deliver speed with:

- High efficiency and minimal fuel consumption
- Emissions within regulated limits
- Acceptable cavitation to avoid erosion
- Noise and vibration within habitable limits
- Consideration of off-design dynamic power demands

Successfully delivering speed for a client is rightly considered by naval architects as a systems engineering task. The big and high value decisions are best achieved by first properly specifying the connected performance of the hull-propulsor-drive system components. While it is common for naval architects to be intimately involved in the selection and integration of engines and transmissions — including their structural interface with the vessel — it is less common that naval architects are involved at the same level of design or engineering for propulsors. For many, the responsibility for successfully delivering the propulsor is off-loaded to a specialist or manufacturer, with little (if any) input over the final design given by the naval architect.

For propeller-driven craft, it is now imperative that naval architects understand in greater detail about the propeller that is being proposed for their vessels. While their job is indeed to evaluate the system, everyone benefits when the naval architect is also involved in the specification and design of the propeller. Not only are client outcomes more successful (making everyone happy), but company risk is lessened, expectations are better shared with manufacturers, and hull form design can be influenced and improved.



Radial definition of blade element slices

So, what does it take for a naval architect to acquire the necessary engineering knowledge on behalf of a client? Let's start to answer that question by reviewing the propeller design process.

Stages of the propeller design process

Propeller design follows an iterative process of refinement, often referred to as a 'design spiral'. During this engineering process, the design matures across multiple evolutionary revisions. A 'solution' is identified at each stage that conforms to an increasing level of detail. The principal stages for propeller design are generally:

1. Identification of principal system characteristics
2. Determine optimum radial distributions of blade shape
3. CAD development of the propeller geometry
4. CFD and FEA analysis for advanced requirements
5. Validation by model testing

Principal system characteristics

Most naval architects are well versed and comfortable with the tasks in Stage 1, where the propeller's performance requirements are established. A tool such as the HydroComp NavCad software is used for this task, for example. A resistance prediction typically establishes the propeller's thrust requirement, and a propulsion system analysis predicts hull-propulsor interaction (such as wake fraction and thrust deduction) and the propeller's corresponding developed thrust.

This stage also is typically where the propeller's principal characteristics and operating rpm are defined. An optimum combination of propeller parameters will be calculated and specified to meet not only the required thrust at speed, but to do so in a way that also meets diameter restrictions, maximum efficiency, thickness requirements (for class rules as needed), engine power constraints, and acceptable cavitation levels. With some software (such as NavCad), an initial assessment of noise and vibration can also be conducted. At this stage, the propeller is described by the following characteristics:

- Configuration (open or ducted) and style (e.g., B Series, Gawn, Kaplan, NACA)
- Blade count, diameter, mean effective pitch, and blade area ratio

Calculations to identify these characteristics are carried out using parametric-empirical methods (also known as [1D] methods). When applied correctly, they can be very capable tools to determine component characteristics for the purposes of system analysis (and to specify final propellers that are of a stock design). They will also provide the framework for continuing to higher-order, more-detailed propeller design or analysis.

Radial distributions of blade shape

The next level of calculation detail — and the deepest level of propeller design probably needed by most naval architects — is conducted using a 'wake-adapted' propeller

design tool (HydroComp PropElements is a good example of such a tool). This simply means that it allows the user to define the velocities (i.e., the wake field) into the propeller with a greater level of precision. This is often referred to as a [2D] calculation, as it increases the order of detail from just the principal parameters and allows for radial refinement of propeller blade shape into 'element' slices.

In the 'parametric' [1D] calculation in Stage 1, for example, the velocities are described by speed and wake fraction. In Stage 2, these are further refined within the propeller's radial coordinate system. For the purposes of the [2D] order of calculation, the full wake field is typically simplified into 'circumferentially-average' velocities versus radial position.

The [2D] analysis also predicts velocities that are 'induced' by the propeller rotation, both axial and rotational (tangential). These induced velocities are organised with the wake field velocities into a set of vectors that describe how the blade section foil shape 'flies' through the water. Note that proper [2D] propeller calculations must also consider additional flow corrections for blade thickness, curvature, and compression. It is at this angle of attack and inflow velocity that the lift and drag of the foil can be predicted, the body forces at each radial position determined, and the thrust and torque integrated for the entire propeller.

The calculation methodologies of this stage can also computationally determine optimised distributions of pitch and camber (mean line) to meet a thrust or power requirement. Cavitation checks are available on each radial section in more detail than the [1D] 'whole-propeller' review of cavitation percentage, for example, which can aid in the selection of specific chord length. A strength calculation based on enhanced beam theory offers additional blade thickness refinement. The design can be modified in the [2D] setting in a way that it cannot for a [1D] calculation, such as to 'unload' the blade toward the tip or hub (typically for hydroacoustic or vibration purposes). Finally, the optimised propeller is then evaluated for thrust, efficiency, power, cavitation, and additional performance metrics.

If the performance of the propeller at the conclusion of this stage is sufficiently different from the results from the earlier Stage 1, a full KT-KQ curve can be developed and the system calculations can be repeated for improved speed predictions.

Companion to CFD or FEA

Many naval architectural firms actively promote the use of CFD for their projects. It may be fair to say that at this point in time all naval architects have considered it!

The use of CFD for even deeper analytical review is particularly valid where the ship's mission is highly sensitive to noise or vibration (such as military or cruiseships), where it is very heavily loaded and exhibits substantial cavitation, or where the business plan justifies searching for the last bit of efficiency. Finite element analysis (FEA) may also be justified during this stage. The objective of this stage would be additional refinement of not only the radial distribution of parameters (as was investigated with the [2D] calculations), but also for section foil shape details (e.g., camber and nose shape for an objective pressure distribution).

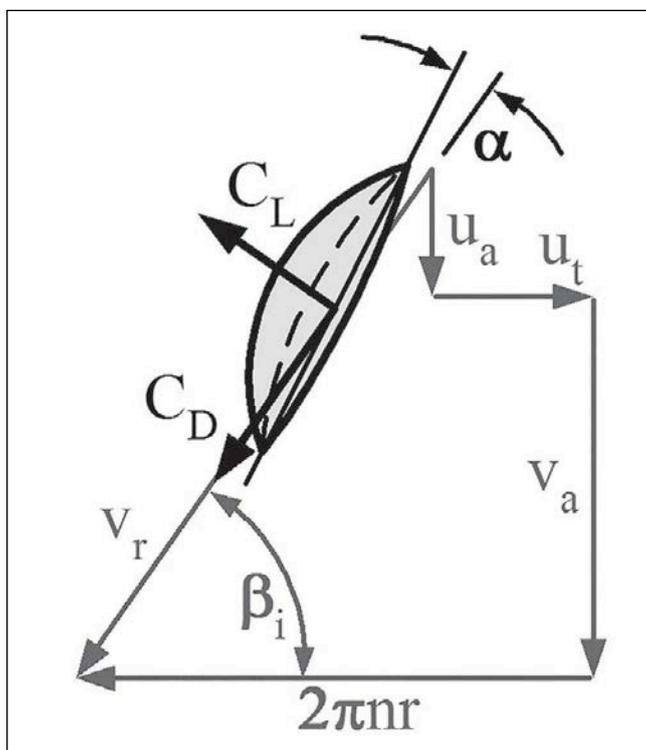
The 'wake-adapted' [2D] analysis is often used to provide the preparatory staging for higher order analysis with FEA or CFD. For example, PropElements can export a polar grid of the 'body forces' and velocities that can be applied as a highly-efficient propeller actuator disk replacement. In fact, employing a [2D] analysis before embarking on CFD can greatly increase its effectiveness by providing a more precise qualitative and quantitative foundation. Conducting CFD studies without a solid [2D] propeller code is like trying to run before learning how to walk — it can be done, but it comes with a lot of pain.

A case for greater involvement

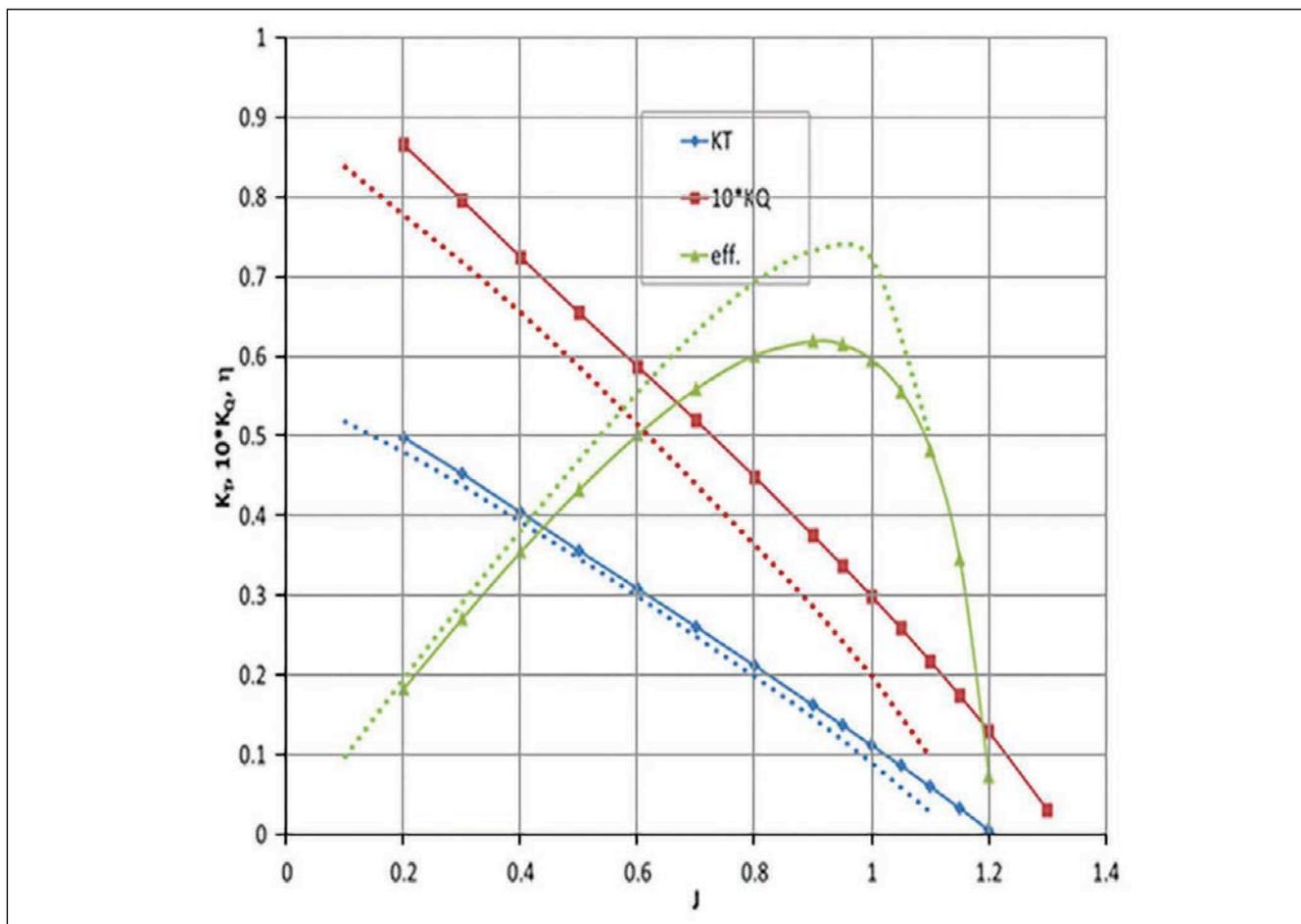
Why should a naval architect be involved in propeller design at a more detailed level? Is it not the job of the naval architect to get the system right? And then hand it off to a specialist if needed? Valid questions.

Let's consider a real case that we observed recently regarding CFD modeling of a propeller for an integrated self-propulsion study. The calculation report showed a KT-KQ curve — with no comparison to a baseline or validation model, just the set of curves. Are the curves correct? It is hard to tell. So, supporting calculations were run with HydroComp PropElements to provide a quantitative baseline check on the calculations. Guess what? Big problems: KT was pretty good, but KQ was greatly over-predicted.

What caused the problems? It was the CAD function in the CFD code. It simplified the sections into a polyline-faceted geometry. This geometric treatment was never caught until the [3D] CFD calculations were checked against the [2D] benchmarks and an investigation started to determine why they were so different. After correcting the



Blade element velocities



Validation study with (2D) propeller code

nose with geometry that was refined to better capture the curvature, the KQ calculation was much closer to the [2D] benchmark.

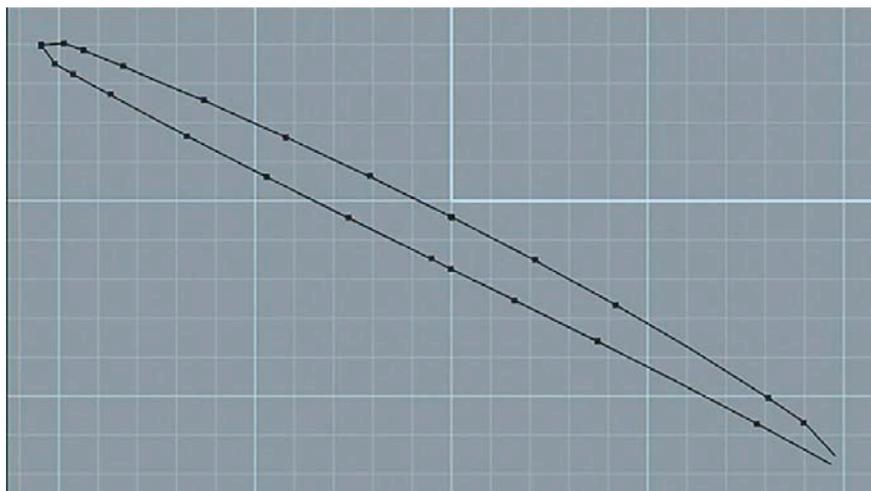
Of course, checking higher order codes is not the only reason for naval architects to be actively involved with more detailed propeller calculations. It is precisely because naval architects are the “keepers of the system knowledge” that they need to be a partner in the propeller design process. A propeller design impacts the system.

For example, let’s consider a hull form that causes a ‘shadowing’ of water velocity behind a skeg. This disruption of uniformity in the wake field might cause excessive cavitation, radiated noise, and structural fatigue failure. Contracted propeller specialists or manufacturers typically only have design authority over the propeller, so they are limited to improvements that they can suggest to mitigate inflow problems

— such things as increased skew, thicker blades, or reduced diameter (to lengthen the hydraulic transmission of pulses), all of which also have a fuel-efficiency penalty. On the other hand, the naval architect can do those things as well, but can also consider changing the stern lines, altering

the shaft angle, looking to a different shaft rpm, and many other measures to improve the propeller component and the system. It is certainly appropriate in many projects to involve a propeller specialist, but it should always be done with knowledgeable interaction from the naval architect. *NA*

Inaccurate polyline simplification of blade shape



Kawasaki's new LNG tank concept gets AIP

Japanese Kawasaki Heavy Industries (KHI) has received an Approval in Principle (AIP) from ABS for its non-spherical shaped LNG tank

KHI first requested a design review of its non-spherical MOSS-type LNG tank by ABS back in August 2016, and now the concept has been awarded an Approval in Principle (AIP) by the classification society.

The IMO Type-B tank has been designed with the aim of making better use of space on-board a Panamax-size LNG carrier. When compared with a traditional spherical tank, the new design increases the total carrying capacity of a Panamax from 155,000m³ to 180,000m³ — an increase of 25,000m³.

Several shapes with different curvatures were considered but the non-spherical shape was chosen as being “most suitable in the light of strength and productivity”, according to Takumi Yoshida, manager for structure planning section, initial design department – engineering division, ship & offshore structure company, KHI.

The initial concept has been designed for Panamax LNG carriers, with a clear eye on the growing trade in US LNG exports transiting through the expanded Panama Canal to Asian markets. However, KHI is optimistic that the principle could also work for smaller vessels: “With the non-spherical concept, ships’ breadth can be reduced without sacrificing the cargo volume, so smaller LNG carriers can also achieve the reduction of hull steel weight and fuel consumption,” continues Yoshida.

According to KHI, there will not be much change in pressure distribution in the tank because the non-spherical design still consists of a continuous curved surface, as in the spherical design. The shape also doesn’t appear to have any bearing on the boil-off gas handling.

Despite the obvious advantage that the new shape increases the LNG carrying capacity without a commensurate upscaling of the vessel, Yoshida admits that the design presents some engineering challenges compared with



KHI's non-spherical tank design will increase the total LNG carrying capacity on board a Panamax vessel

the better-known spherical design: “The non-spherical shape needs some improvement in production method and tolerance control for bending work of the curved shell.”

Given the advantages of increased capacity and operational efficiency, the Japanese technology giant is confident that the industry will embrace the unconventional design: “Since the non-spherical concept succeeds to the concept of the original MOSS-type tank and can carry more LNG cargo, we think it will be accepted by the customers. We are looking forward to the first order,” says Yoshida.

When it came to making a decision on the AIP, ABS was aware that KHI's experience in the field would stand it in good stead, as Makoto Oba, director, technology and business development Japan, ABS explains: “While ABS recognises KHI has lots of experience

building spherical LNG tanks (MOSS) and MOSS-type LNG carriers, ABS considered whether KHI correctly paid attention to specific failure modes and behaviours of non-spherical tanks due to structural difference. ABS has experience approving a non-spherical LNG tank design by another shipyard and provided support to obtain USCG approval for the design. Based on this past experience, ABS could easily make the decision on the AIP.”

Hideaki Naoi, ship & offshore company general manager for the engineering division, KHI adds: “With the Panama Canal expansion and LNG demand increasing, owners and operators are looking to gain efficiencies without compromising safety. This new concept adds 15% more carrying capacity while maintaining the size of the new Panamax tankers. By working with a proven technology leader like

ABS, we were able to prove the feasibility of this innovative design.”

The new design can also be used in conjunction with the Kawasaki Panel System — a system of panels used to insulate spherical (MOSS type) and cylindrical cargo tanks of LNG carriers. The system was used on the first Japanese-built large-scale LNG carrier, *Golar Spirit*,

back in 1981 and is said to provide the highest insulation performance in the world, with a 0.1% boil off rate per day, according to KHI.

Kawasaki’s design has also been given an AIP by DNV GL, which carried out sloshing and buckling analyses with KHI, proving the non-spherical design to be as safe as the traditional spherical

design. An AIP essentially means that the design has been deemed feasible and without significant obstacles to prevent the idea from being realised. It typically takes place towards the beginning of a project to not only reassure the designers of its feasibility, but also external investors, regulators and potential customers. **NA**

Don’t neglect automation, warns Høglund

Giving proper consideration to automation at the design stage can boost efficiency and avoid awkward questions further down the line, the CEO of Høglund Marine Automation tells *The Naval Architect*

With imperatives such as the 2020 global sulphur cap, it’s more a case of ‘when’ rather than ‘if’ LNG establishes itself, and a new generation of LNG carriers is emerging to meet the growing demand for bunkering services. Typically, these vessels have complex requirements, in particular the use of boil-off gas to burn in their engines via a fuel gas control system. Similarly, some LNG bunkering barges must also extract vapour from receiving ships to use as fuel. To achieve this requires additional interfaces between the gas plant and the rest of the vessel and the integrated harmonisation of multiple on-board systems to ensure optimal performance.

One company that has sought to position itself at the forefront of this growth sector is Høglund Marine Automation. Founded in the early 90s, the Norwegian company develops and delivers both standardised and bespoke hardware and software solutions and LNG carriers have become a particular specialism, with its integrated automation systems (IAS) currently incorporated onto 16 LNG carriers (around 12% of the global fleet). In April this year, it was announced that it would be providing the IAS for Bernhard Schulte Shipmanagement’s (BSM) forthcoming 7,500m³ LNG bunkering vessel, to be built at Hyundai Mipo Dockyard in South Korea. In addition, Høglund Marine Automation will supply



Børge Nogva

the vessel’s power management system, power failure control, playback with fast data capture, redundant controller and remote service and support.

Using the plans for the BSM vessel as an example, Børge Nogva, Høglund’s CEO, explains: “What we do is make a centralised automation system which can contain a number of subsystems, and this is what’s known as an IAS. The system allows the operator to sit and see everything that’s happening, including fire detection systems, gas detection systems, tank levels, dual-fuel generators, steering gears — all the various systems onboard usually have some link to the automation system. If they’re not working, or overheating, then an alarm signal comes back.”

The challenge for Nogva and Høglund is that automation is often treated as an

afterthought by ship designers, owners and shipyards. He says: “We of course think automation is very exciting and that owners and designers should discuss in much more detail how the automation system should work when they start a new project. But instead they come to us halfway into the project — or even when it’s finalised — and ask whether they can have certain capabilities. You could, if you had thought about it and discussed it earlier. Now it’s going to cost you an arm and a leg to do it!”

The consequence is operator stations lacking the functionality desired by the owners, or a convoluted set-up whereby anything up to six different suppliers may have separate screens. “One is controlling all the valves, one is controlling all the pumps, one is controlling the cargo system, one is the fire detection system, etc. So we are trying to get to the owners and designers early so that they give proper consideration to what should be integrated and what should be left as a standalone system.”

Determining precisely what should be included and where responsibility should lie is becoming increasingly challenging, with control of modern vessels often being handled by multiple stakeholders. In the case of the BSM project, the cargo handling system is being developed by Babcock International in Edinburgh, incorporating Babcock’s zero-emission

Concept image for BSM's LNG bunkering vessel, for which Høglund will provide an automation solution



FGSV0 system. “Of course Babcock wants to control what goes in and out of these tanks, to monitor temperatures and pressure levels with its own interface. So you include Modbus serial communication which means we can get information from the tank system and send it to Babcock.

“But they are the ones controlling the valves and pumps. So if a valve were to develop a problem — for example, if it has stopped for some reason so that an alarm goes off — they could send that alarm to us, but somebody still has to press the button to stop the alarm. But who should do this, the automation guys or the cargo guys? There’s an ambiguity in who should do what but somebody has to be responsible for acknowledging the alarm and acting on it. You can’t have ambiguity because this is gas and it could blow up.”

Persuading shipowners and designers to take automation more seriously can lead to systems that are both cheaper and more functional, according to Nogva. With remote monitoring from shoreside Høglund’s technicians are able to conduct servicing — for example with the calibration of a newly-mounted heat sensor — instead of having the vessel’s onboard crew frustrated in their attempts to align multiple systems. “The funny thing is many owners believe that this situation is not possible to fix because they are used to automation systems not working very well, if at all. Every owner we meet nowadays is very engaged with the question of lifetime costs so it is important to increase their awareness that automation can matter and deliver a more efficient ship.”

Because automation is a concern many owners would sooner dispense with, larger companies, such as Rolls-Royce and Wärtsilä, often include these interfaces as part of a larger equipment package. Nogva, who spent 14 years with Rolls-Royce, believes many come to regret their decision, but that a single service contract is often deemed preferable to splitting among multiple suppliers.

Moreover, shipowners may not have sufficiently qualified technical staff or partners with whom to consult on such matters. “In general the designers don’t know anything about automation, or even electronics in many cases. So our work is to explain to them they shouldn’t accept systems from these big suppliers so easily. We give them a list of questions they should be asking and suddenly the glorious Powerpoint presentation [by the supplier] is broken up into numerous challenging matters which the owner needs to understand before saying ‘yes.’”

Educating designers

Nogva has plenty to say about how designers could be better educated on matters of automation. “If you look at the ship design specifications, if it is based on SFI Grouping, then you find automation covered under Chapter 7.9.2 and alarm systems. When we read it it’s like reading the Bible upside down. Why would they say a ship needs a ‘modern, computerised alarm system’? It’s like saying a ship needs an engine so it can turn around, it’s on that level.”

He adds that even good designers will often copy the alarm system text from elsewhere for the specification, even if it’s not strictly applicable to that design. A better practice, Nogva believes, would be to include it within the general chapter outlining the vessel’s intended purpose and the standards it needs to be built to. This could set

down what subsystems (e.g. power management, gas detection shutdown, cargo control) should be encompassed by the particular IAS and which ones excluded. But he is sympathetic to the demands and expectations on designers: “They are more concerned with things such as speed, power and hull structure which they need to understand 100%, or the vessel is a failure. If they fail on automation it’s not a disaster.”

It’s more about raising awareness, particularly when shipowners confront the designers and yards with awkward questions about the choice of an inadequate system because they were assured the extra cost wasn’t worthwhile. “They have an operational profile of the vessel they want to achieve. The vessel is supposed to operate in a certain environment and if we are told what that is, we can create, for instance, a power management system that makes it more efficient.”

“Then later on when the owner gets the ship and it has to comply with the EU and IMO rules on reporting — and has included that simple extra functionality — it avoids a situation where the crew has to make notes on yellow post-its saying how far the ship has travelled and estimated emissions. The system can do all this automatically, extract the data and send it to the owner via email. Imagine how much time and money that simple extra functionality could save.”*NA*

Top ships: better insight in inland ship stern design for shallow water

Erik Rotteveel and Robert Hekkenberg, both of Delft University of Technology, Department of Maritime and Transport Technology, Netherlands, discuss a new Joint Industry Project that aims to optimise ship design based on water depth

An important aspect of a newly designed inland cargo vessel is its fuel consumption during navigation. With a growing focus on reducing fuel consumption and the related emission of CO₂, particulate matter and NO_x, inland ship designers are looking for ways to achieve better fuel efficiency. This is possible by several methods: by installing fuel-efficient engines; by lowering the required amount of propulsion power by using a navigation speed advisor; optimising the navigational track through the rivers, or equipping the ship with an optimised propeller and/or improving the hull form. The last option is the focus of the Top Ships project.

Top Ships is a Joint Industry Project (JIP) by the Delft University of Technology, Maritime Research Institute Netherlands (MARIN) and multiple companies involved in inland ship design, including Conoship International B.V., which has designed multiple sea-river cargo vessels, SARC, that delivers stability software and advice on damaged stability, and Sip Marine, a propeller design company that has delivered designs for inland ships as well. The project focuses on the stern of an inland cargo ship. Various aspects and design parameters for the stern of an inland ship are considered and analysed in order to assess their effects on the required propulsion power.

The stern of an inland ship was chosen as the focus of the project due to its complexity and the limited extent to which it was understood. Not only does the design of the stern affect the resistance of the ship, it should also ensure that the flow towards the propeller(s) is appropriate to achieve high efficiency and avoid uncomfortable vibrations. Given the very full (high block-coefficient) form and appendages such as propeller tunnel skirts, propeller ducts, propeller outflow cover plates, rudders and headboxes, this is not an easy task. The tunnel

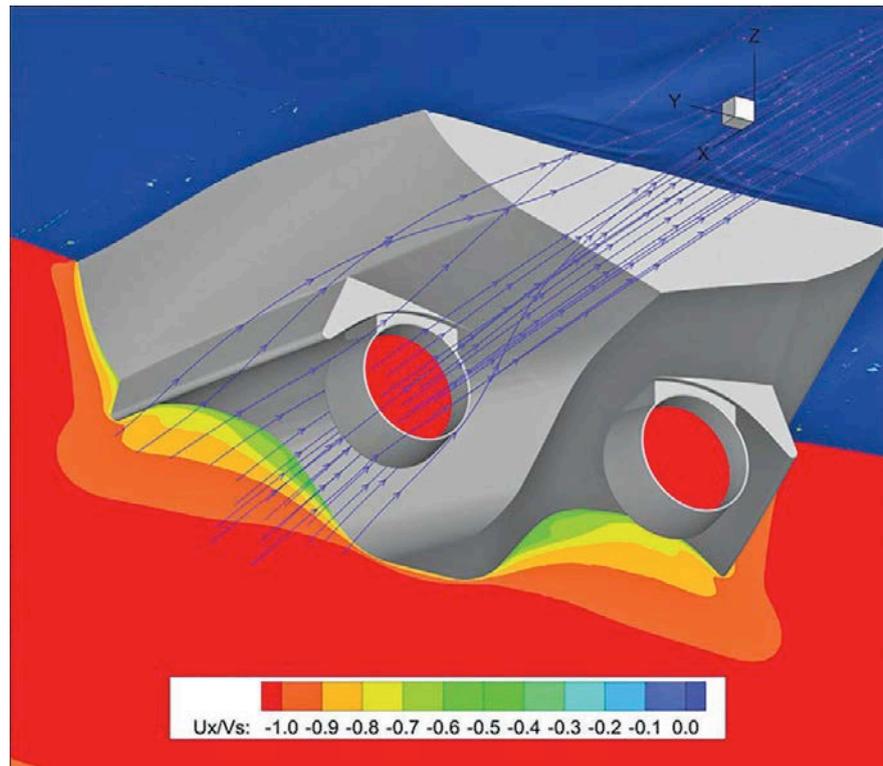


Figure 1: Picture of the flow (obtained with ReFresco) around the stern of an inland ship. The skirts of the tunnel are shown as well as the propeller ducts. Also, a cut-slice of the flow in x-direction is given. The blue curves are flow tracers, showing that the non-uniform flow in the cut-slice will pass through the propellers

skirts and propeller ducts are presented in Figure 1, together with specific flow features.

Apart from the complexity of the ship design itself, the navigational environment poses challenges. Inland ships almost constantly sail in shallow water which makes it difficult for the flow to approach the propellers. Moreover, the water depth affects the trajectories of the flow in such a way that the optimal stern design even depends on the water depth that the ship is designed for.

These complexities of inland ship sterns form one of the primary reasons why data — that can be used to both predict and

improve propulsive performance - are hard to come by. The only accurate ways to predict and improve the propulsive performance of an inland ship is by model tests or CFD calculations. In fact, even model tests require careful analysis due to additional scaling effects occurring in shallow water. To really optimise the ship, multiple water depths should be taken into account in tests or simulations, since the ship will encounter this during its operation. Model tests or CFD simulations therefore become very expensive.

The main goal of the project is to gain insight into the effects stern design can

have on the propulsive performance of an inland ship, in multiple water depths. With this insight, ship designers are able to obtain a better performance prediction of an inland ship earlier in the design process.

At the early design stage, trade-offs can still be made between, for example, a larger cargo hold (and thus a high-block stern) and a more slender hull form (with a better, more uniform flow towards the propellers). This trade-off involves the length of the stern (i.e. the distance between the parallel mid-body and the transom). This parameter would not affect the outcome of most existing empirical power estimation tools, since those tools are initially built for use with sea-going ships. Although the block coefficient of the inland ship is changed by the stern length parameter, this change is very small, leading to no significant effect in existing empirical tools (that usually include an input for the block coefficient).

In order to achieve the goal stated above, the first step is to identify the relevant inland ship stern aspects that are investigated in the project. Among them are the length of the stern region, bilge radius in the stern and the athwartships propeller position. Furthermore, additional parameters are identified that describe the shape of the bottom plane, the design of the tunnel skirts and the width of the transom, for example.

Next, the identified hull form aspects are used to develop a parametric model, in which multiple stern designs are defined and new designs are generated by interpolating between the defined hull shapes. Multiple sets of inland ship sterns are generated in this way. As an example for this article, a sample is used that consists of 300 inland ship sterns, each varying with respect to the aforementioned parameters.

To assess the propulsive performance of each ship, the CFD code Parnassos, developed at MARIN and Instituto Superior Técnico (IST) Portugal, is used. Parnassos is an efficient flow solver, requiring between five and eight hours to compute the flow around a ship under consideration. Therefore, the code is very suitable for use on the Top Ships projects, in which a large series of hull forms is investigated. In Figure 3, an overview of the used domain is presented. Calculations are conducted at three different water depths, corresponding to depth-to-draft ratios of 3.0, 2.0 and 1.5.

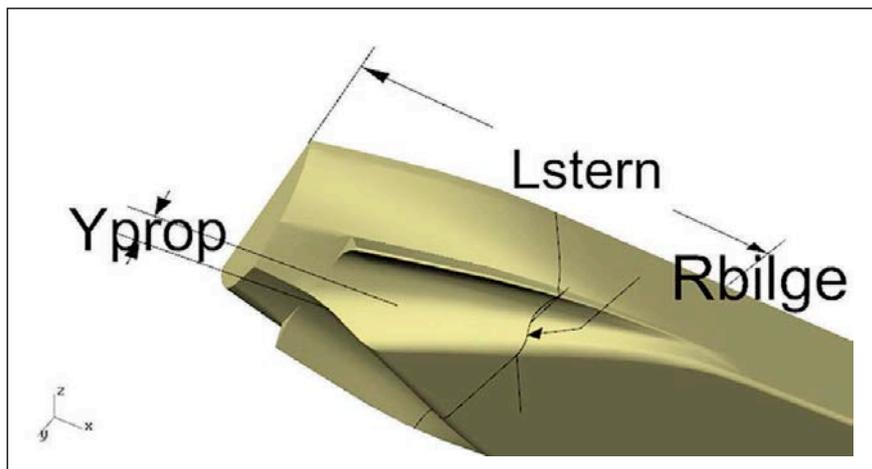


Figure 2: Example of the stern of a double-propeller inland ship. The shown parameters are the length of the stern region (L_{stern}), the bilge radius (R_{bilge}) and the athwartships propeller position (Y_{prop})

Modelling of the propeller is done through a force field located at the propeller position that resembles the thrust force distribution that a propeller would produce.

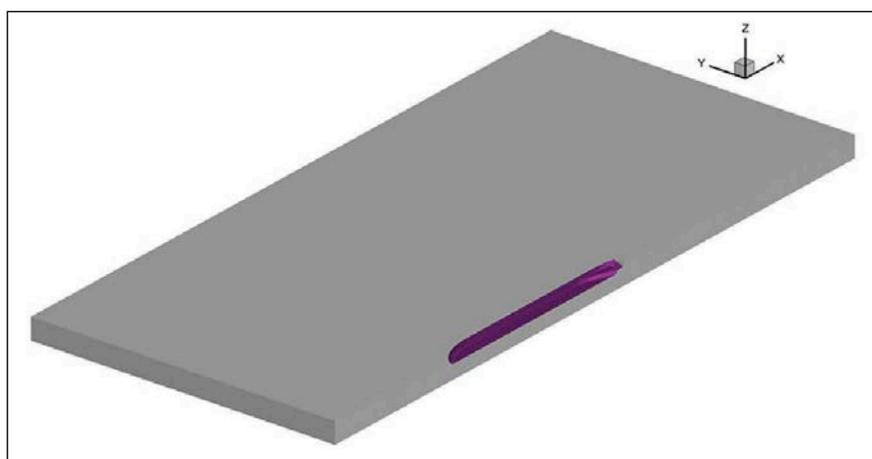
From Parnassos, the resistance of the ship, as well as the wake-field, is obtained. From the wake-field, which is the flow distribution at the propeller plane, the effective wake fraction is computed. This wake fraction then serves as advance velocity in open-water propeller diagrams, which are used to obtain a propulsion power estimate.

Another value obtained from the wake-field is a measure of the non-uniformity of the angles of attack that the propeller is facing. This value is an indicator for the risk of cavitation: if the propeller is highly loaded, and variations of the angle of attack

are estimated to be high, the angle of attack may be too high in a certain portion of the propeller circumference, leading to cavitation and thereby vibrations. This measure, referred to as the 'wake object function', is part of a common trade-off in propeller design: higher angles of attack lead to higher efficiency, but if the variation of angles of attack is too large (and thus the angle of attack too high at certain locations), vibrations and noise occur.

After performing the series of CFD calculations, the results must be analysed to firstly investigate the effect that a certain parameter has on the power prediction and the wake object function, and secondly to construct a model that allows for the prediction of performance of inland ships as well as to analyse the effects of changes

Figure 3: Overview of CFD domain, with the ship indicated by the purple area



to an inland ship. Before this can be done, however, it should be noted that for efficiency reasons, the included parameters have not been varied in equal steps as it would have led to over 50,000 calculations. Instead, the parameters have been varied such that the generated hull forms are distributed as uniformly as possible throughout the common variation range of all parameters (the design space). This is achieved by an optimised Latin Hypercube Sampling procedure, allowing the performance of much fewer computations while still finding the effects of the parameters involved. However, an additional step needs to be taken since the stern shapes cannot be compared one-by-one.

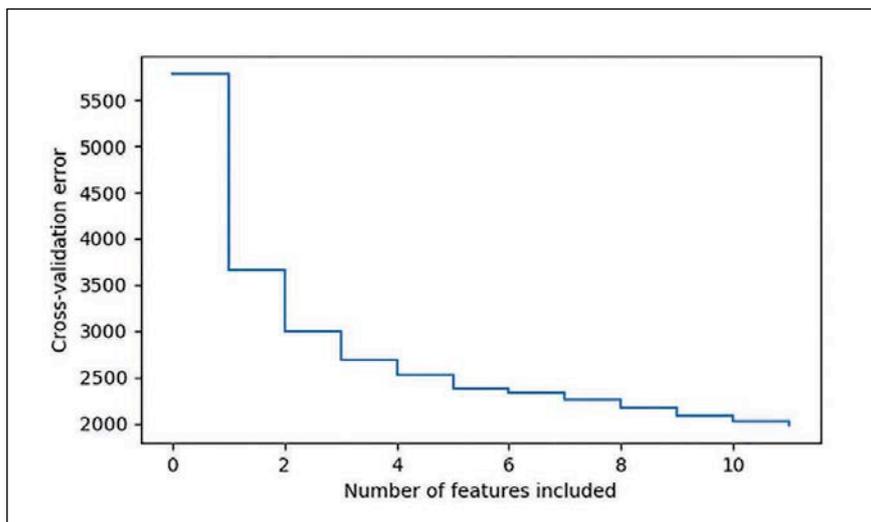
This additional step is called 'surrogate modeling'. In surrogate modeling, we replace an expensive simulation (CFD in this case) with a cheaper model that can quickly generate 'new' estimates of propulsion power and the wake object function. Apart from speed, another advantage is that a surrogate model allows the user to change only a single parameter between two 'new' estimates, again allowing a one-by-one comparison. Furthermore, this allows us to estimate the effect that a specific parameter has on propulsion power and the wake object function, and thereby to identify

the most important aspects of an inland ship hull form.

Parameter influence estimation is done by feature selection: multiple surrogate models are generated, each including one or more parameters under investigation. For each number of parameters included (from 0 to all), the models with the best combinations of used parameters are kept. Then, analysing the predictive performance of each of these models and checking which parameters are used in each model, the influence of a parameter is estimated. Figure 4 shows such an analysis, where the predictive error reduces upon addition of more parameters.

From Figure 4, it can be observed that the majority of the variation of propulsion power is due to only a few parameters. In fact, the variation is only due to the length of the stern region and the athwartships propeller position. If this Figure was created from shallow water (Figure 4 corresponds to relatively deep water, $h/T = 3.0$), the most important parameters would still be the same as for deep water. However, we will see that other parameters become even less important, in comparison to the importance of the first two. This is a significant observation: in shallow water, most of the variation in propulsion power between ships is defined by fewer parameters than in deep water.

Figure 4: Parameter influence analysis for the 300-ship example set at $h/T = 3.0$. In the case that there are no parameters in the model, it can only predict the mean value of the data, and the RMS error (vertical axis) between predictions and data is equal to the standard deviation. By increasing the number of included parameters (horizontal axis), the error decreases down to less than 10% of the spread of propulsion power data



The surrogate models are also used for optimisation. Using evolutionary algorithms, it is possible to optimise the ship for each water depth separately, using a displacement constraint. From this, another observation can be made — that the optimal stern design changes in shallow water compared to that in deep water. This is due to the different orientation of flow trajectories in shallow water — the bottom of the waterway decreases the freedom of the flow to move in a vertical direction, and a larger portion of the flow therefore passes around the ship along the sides rather than underneath. This also leads to the effect mentioned earlier, that the estimate of propulsion power depends on fewer parameters.

Finally, the surrogate models can give answers to questions such as: “Which parameters should be adapted first in order to lower the amount of required power for propulsion?”, or “What is the effect of water depth on the optimal ship design?”. These answers will be reformulated as design guidelines, applicable to inland ships with varying main dimensions, having either a two-propeller or single-propeller tunnel stern or a pram-shaped stern.

Aside from the design guidelines, the surrogate models will be reformulated into a model that is useable in practice, based on parameters that can be computed from an inland ship — existing or new — in order to estimate the required propulsion for that ship. The model will, as with any model, have its range of applicability defined by the ship and parameters that have been tested in this project.

Eventually, inland ship designers are thus left with more knowledge on which stern shape aspects they should focus on in order to improve propulsive performance, along with a performance estimation tool that can numerically show how each of the parameters affects the propulsion performance. With both, designers can make better trade-offs between more cargo, less fuel consumption, a lower chance of cavitation and optimisation for a specific water depth.

The Top Ships project is currently in its final stage and will be completed by the end of 2017. The results will become publicly available two years after completion of the project. [NA](#)

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Choosing the safest wave

Sanne van Essen, MARIN, and Herman Peters, Rijkswaterstaat, Netherlands investigate the wind and wave design conditions to study the minimum power ships need to safely and efficiently navigate the southern North Sea

New energy efficiency rules like EEDI are driving a reduction in the installed power of vessels, but this should not come at the expense of safety and operability in waves. This was recognised by the IMO [6], but small ships (less than 20,000dwt) frequently operating in Dutch waters are exempt from these interim guidelines. Therefore, the Dutch government cooperated with MARIN, as well as Dutch shipowners, builders and designers, to evaluate the minimum power requirements for a typical small ship sailing in waves in the southern part of the North Sea (SNS). The total resistance of a vessel at a certain speed consists of calm water resistance and added resistance due to wind and waves. Given that the wind and wave drift forces can significantly increase the total resistance, the choice of environmental conditions at the start of such a study is critical. This article evaluates the influence of commonly-applied environmental assumptions on drift forces experienced by a typical vessel sailing in the SNS.

The wind-wave climate

A wind climate is an easy way to characterise an environment, for instance, in terms of the probability of occurrence of Beaufort numbers. These wind classes are often related to area-dependent ‘average’ wave conditions. However, this approach fails to recognise that one wind speed can come with a wide range of wave heights and periods, strongly depending on the fetch and duration of the wind. Wind speed and direction are highly variable, therefore meaning that wind and waves are never in equilibrium. The most important parameters used to characterise a wave climate for maritime studies are the height, frequency distribution and directional distribution

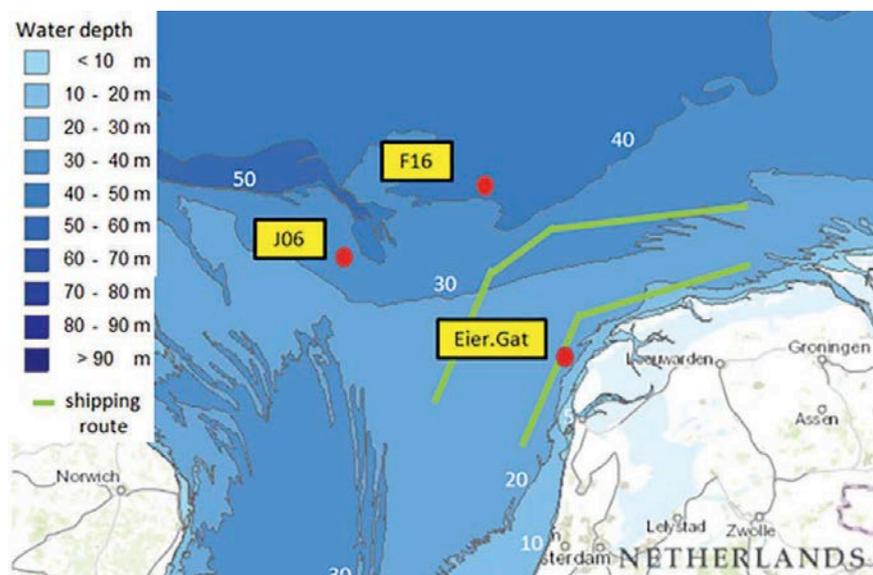


Figure 1: SNS area with wave buoys, water depth and typical shipping routes (courtesy of Rijkswaterstaat)

of both the locally-generated ‘wind sea’ and the ‘swell’ wave energy from distant sources. The motion response of ships strongly depends on the wave period, so the fact that one wave height can occur with many different wave periods is important. This indicates that design conditions should at least contain information about the joint statistics of wave height, wave period, wind speed and the distribution of wave energy over the periods around this typical period.

If wave measurements are available in a certain area, they are usually presented in the form of wave scatter diagrams, reflecting the joint statistics of significant wave height and wave period. Wave period can, for example, refer to the peak of the spectrum (T_p) or the average time between two zero up-crossings (T_2). In most cases, T_2 is used in scatter diagrams. Wave frequency is directly related to wave period.

A ‘wave spectrum’ describes the distribution of wave energy over the frequency components around T_p or

T_2 . It is characterised by a significant wave height (H_s), a peak enhancement factor (γ) and information on the wave period. The relations between the wave period definitions depend on the spectral shape. The spectral shape varies with the development stage and direction of the waves, but it is common practice to adopt a fixed spectral shape. The well-known JONSWAP spectrum is commonly applied for waters with a limited fetch. A wave spectrum also has a directional distribution, but this is not considered here.

As explained earlier, wind speed does not have a unique relationship with wave height, which makes it hard to find wind speeds corresponding to a given scatter diagram when no wind data is available. However, basic methods to estimate wind speed use the fact that wave period shows some relationship with combinations of wave height and wind speed (v_w , 10m above the surface), even for non-stationary conditions. Systematic calculations with varying spectral shapes suggest the

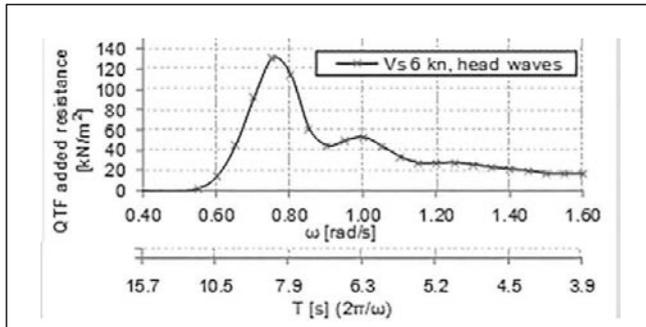


Figure 2: QTF added resistance in head waves at a speed of 6 knots for a 110m tanker

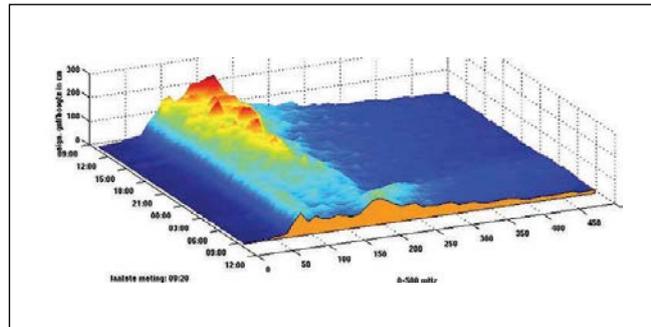


Figure 3: Typical evaluation of wave spectrum over one day at EG (4-5 Feb 2016) given in mHz

following average relation for locally generated wave fields [3]. The following formulation relates high wind speeds to short, steep waves. In the remainder of this article, this is referred to as the ‘MARIN method’:

$$v_w = A.T_2^B.H_s^E \text{ and } E = C.T_2^D, \text{ with empirical factors } A \ 80.443, B \ -1.8421, C \ 1.6012 \text{ and } D \ -0.0474.$$

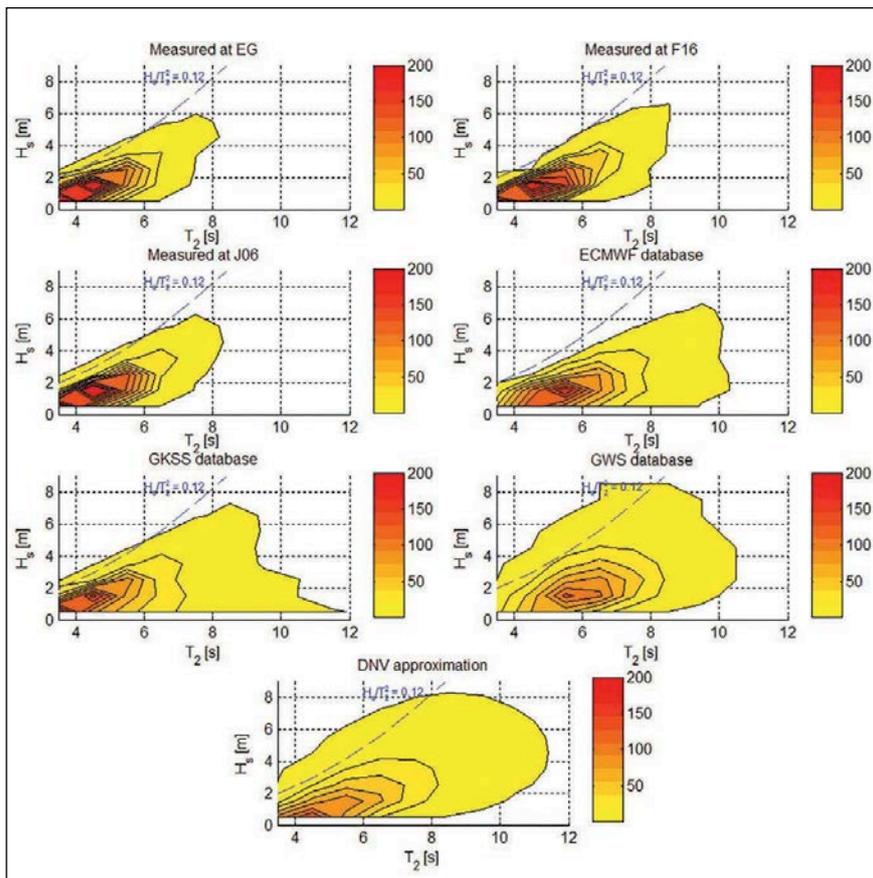
Drift forces

Wave drift forces on a vessel are generally expressed as a quadratic transfer function (QTF), which can be obtained from model tests or calculations. First, a representative wave condition is selected from an appropriate scatter diagram. This could be one of the design wave conditions discussed at the end

of this article. Using the selected wave height and period, a wave spectrum can be generated. Wave drift forces are then estimated based on the QTF combined with the wave spectrum $S(\omega)$, where ω is wave frequency. The frequency-dependency of the wave force is therefore a combination of the wave spectrum and the QTF:

$$F_{waves} = 2 \cdot \int QTF(\omega) \cdot S(\omega) \cdot d\omega$$

Figure 4: Measured and database wave scatter diagrams for the SNS - annual, all directions (outer yellow area indicates occurrence of 1/1000; subsequent lines indicate an occurrence of 20-40-60...200/1000), including approximated maximum steepness line $H_s / T_2^2 = 0.12$



Wind drift forces are generally expressed by wind coefficients (C_x in x-direction, which is non-dimensionalised with frontal area, A_x , and assumed to be independent of wind frequency). Using the density of air, ρ_{air} , and the relative wind speed, $v_{w,rel}$, wind force can be calculated as below. Wind coefficients can be obtained using calculations or wind tunnel tests. Note that wind coefficients in x-direction for vessels are often higher in bow-quartering wind direction than head-on direction:

$$F_{wind} = 0.5 \cdot \rho_{air} \cdot C_x \cdot A_x \cdot v_{w,rel}^2$$

An example vessel

A 110m full-block tanker was selected as a typical small ship sailing in the SNS. The calm water resistance of this vessel at a speed of 6 knots is around 200kN. The QTF of added resistance for the ship at different speeds in head-on direction are shown in Figure 2. These values were obtained using MARIN’s Rankine source calculation program, Fatima. The figure shows that the added resistance at lower speeds is highest in relatively short waves. This suggests that it is important

to obtain a good description of the wave energy for T_p around 7-10.5s (T_2 5.5-8s) – the assessment of drift forces depends primarily on the short ‘wind sea’. A_x of the ship is around 140m² and C_x in head-on direction around 0.57. Added resistance mainly depends on the pitch response of a vessel, so primarily on its length, and on the entrance angle of the bow. Therefore the results presented here are representative for full vessels with a length of around 110m.

Measurements and databases

Wave data measured by Rijkswaterstaat was available at three locations in the SNS (Figure 1). A wave spectrum was delivered every three hours by a wave buoy for a duration of ten years at the Eierlandse Gat (EG) between January 2005 and December 2014 and by a wave radar for six years at platforms J06 and F16, between February 2009 and December 2014. The typical evaluation of such a spectrum is shown in Figure 3.

Wind data at two of the same locations (F16 and J06) was measured by the Koninklijk Nederlands Meteorologisch Instituut (KNMI). The mean wind speed and other statistics were measured hourly over a different time frame from the wave measurements (March 2009 to February 2017 at J06 and from December 2006 to February 2017 at F16). The KNMI

wind and RWS wave measurements can therefore not be synchronised directly.

If no wave measurements are available in the area of interest, hindcast databases can be used to provide a basis for the design. A few of these databases that cover the SNS are considered:

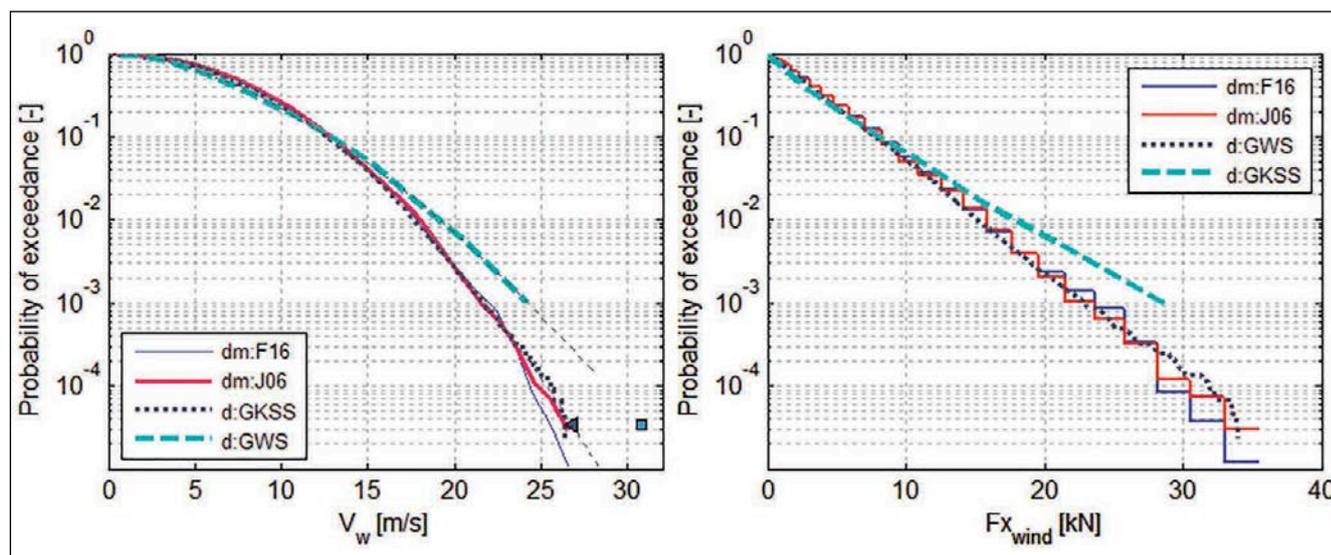
- The European Centre for Medium-range Weather Forecasts (ECMWF) database covers wave statistics (height and period) for the considered area in the years 1994-2001 at hourly intervals.
- The long-term wave hindcast by the GKSS research centre in Germany [4] includes joint statistics of wind speed and wave parameters for the considered area in the years 1990-1999.
- The Global Wave Statistics (GWS) [5] provide wave scatter diagrams and probabilities of occurrence of wind speed. Data for ‘area 16’ of the European database is used. GWS contains statistical information only.
- DNV provided parametrical approximations of the GWS wave scatter diagrams [2]. They are given for the global areas only (not the European database) and global ‘area 11’ was used.

Waves in the SNS

GWS directly provides wave scatter diagrams in the considered area, SNS. GKSS and ECMWF provide time traces

of H_s and wave periods T_1 and T_p only. In order to obtain a wave scatter diagram based on T_p , a JONSWAP spectrum was assumed. The measured scatter diagrams are compared to the hindcast databases in Figure 4. Note that the measured diagrams are normalised to a fraction of 1000. The scatter diagrams of the three measurement locations agree quite well. The waves in the GWS database are much steeper than the measured waves – they seem unrealistically steep, also compared to the breaking limit around $H_s/T_p^2 \approx 0.12$. The measurements agree better with the ECMWF and GKSS data, although the waves in the analysed time frames were relatively low compared to these references. These two hindcast databases seem to overestimate the influence of swell, however (low height, long period waves). The buoy and radar are expected to perform well over the considered swell period range (based on earlier tests done by RWS and MARIN), so the hindcast databases overestimate swell. As the wind on the Dutch Coast is predominantly from the south-west, it seems logical that the area is sheltered by the UK, which limits the influence of swell from distant sources. The measurements all predict lower 10-year maximum significant wave heights (7-9m) than the databases (9.5-11.5m). These values are close to the values predicted by [7] for this area (9.4m).

Figure 5: Left: Distribution of directly measured wind speeds (dm) and data from hindcast databases (d), Right: Distribution of wind drift forces in x-direction for the same sources (steps due to discrete wind speeds)



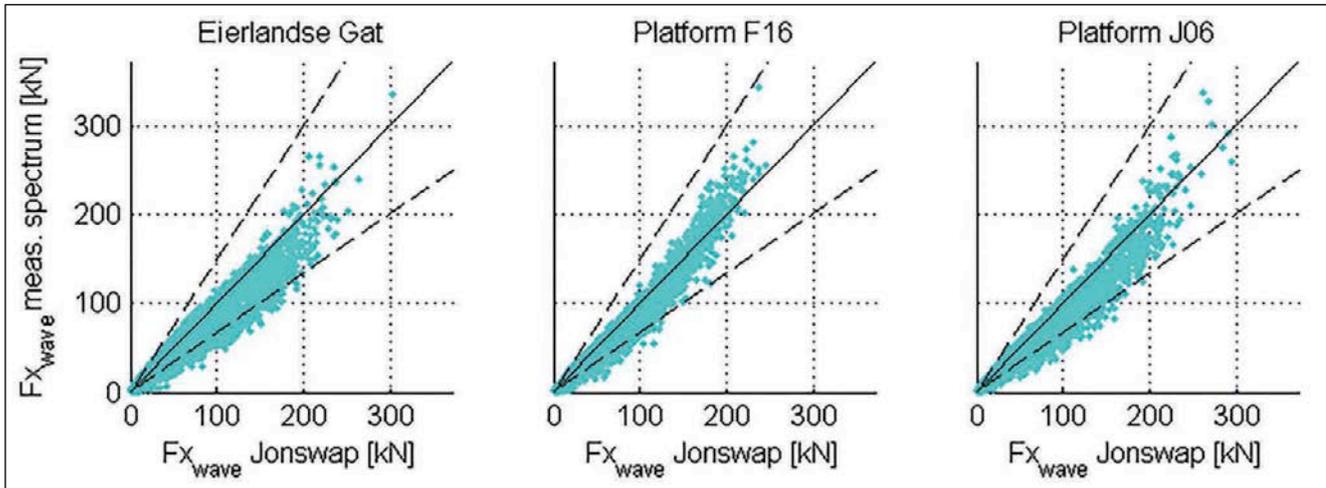


Figure 6: Added resistance in head waves, using measured or JONSWAP spectra (15% error lines)

Overall, it can be concluded that the ECMWF and GKSS hindcast database provide a better reference for the SNS than the GWS hindcast database. However, they still over-predict the influence of swell and predict wave periods that are longer than in the measurements. They also show extreme waves that are higher than in the years of measured data. This emphasis on swell is not expected to have a large influence on the drift forces though.

Wind in the SNS

Figure 5 shows the measured distributions (probability of exceedance) of wind speed, compared to the wind speeds from the hindcast databases. This shows that the wind speed from GKSS agrees very well with the measurements at these locations, whereas GWS predicts extreme wind speeds that are too high. Therefore, this indicates that GKSS could provide a basis for the design wind speeds in the North Sea. The GWS 10-year extreme becomes ~31m/s and the GKSS and measured 10-year extreme ~26-27m/s. These values are close to the 10-year maxima predicted by [7] (29m/s).

The remaining question is how important the differences in estimated wind speeds are for the wind drift forces on a vessel. This is evaluated for the same example vessel referred to earlier, as shown in Figure 5. This shows that GKSS provides a fair approximation of

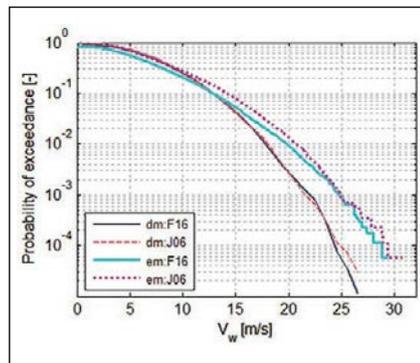


Figure 7: Distribution of directly measured wind speeds (dm) and estimated wind speeds based on measured H_s and T_p (em)

the wind forces, and GWS a conservative estimate for larger wind forces.

Validity of a JONSWAP wave spectrum assumption

The validity of assuming a JONSWAP spectral shape in the SNS is evaluated by comparing the added resistance of a typical vessel calculated using JONSWAP or the measured spectral shape. The JONSWAP spectra were defined using the measured H_s and T_p and $\gamma = 3.3$. The wave drift forces for the 110m tanker at a speed of 6knots in head waves were calculated using the equations shown earlier, and the results are shown in Figure 6. Note that the wave forces can be in the order of the calm water forces in this case.

Similar patterns are visible at the three locations — small forces are generally slightly overestimated

(0-15%) if a JONSWAP spectrum is used, while higher forces are slightly underestimated (5-10%). The spreading increases with increasing forces. Overall, it can be concluded that the JONSWAP shape is an adequate representation of the wave energy distribution in the SNS for drift force calculations with the typical vessel. It generally leads to a conservative estimate (up to 15% too high) of the added resistance, except for a few of the highest waves. This is in line with [1], in which it is also concluded that the JONSWAP spectrum is a suitable description for this area when evaluating manoeuvrability of ships.

Validity of the wind speed estimate

The validity of the ‘MARIN wind speed estimate’ was evaluated using the measured wind and waves. The KNMI wind measurements and wave measurements of RWS are available for the same locations, but not with the same sampling interval, and for different years — they can only be used in a statistical sense. The distributions of the measured wind speeds are compared to the wind estimate based on H_s and T_p measured at the same locations in Figure 7. This shows that the MARIN method proves a fair indication of the lower wind speeds, but significantly overestimates wind speeds higher than ~15m/s (up to 20% for 20m/s), leading to conservative results.

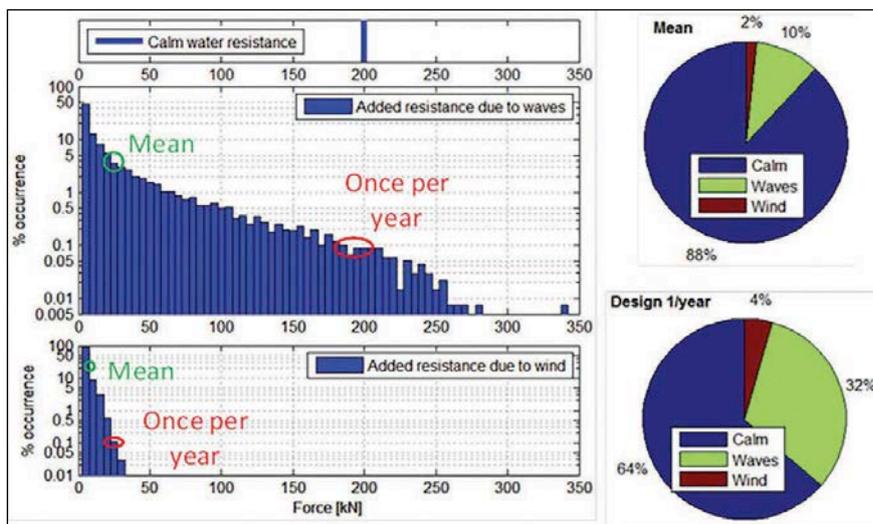


Figure 8: Calm water resistance and wave and wind additions for the example vessel in the SNS, based on measured wave and wind at F16 (left) and contributions for mean measured condition and typical once per year design condition (right)

The importance of drift force contributions

The maximum sustained speed of a vessel in a certain wind and wave condition is based on its total resistance. Figure 8 shows the importance of the wave and wind contributions compared to the calm water resistance of the example vessel, based on the measured wind and wave data. This shows that for a mean wave condition, the wave and wind contributions for this vessel in the SNS are typically 10% and 2% of the total resistance respectively, while they are typically 32% and 4% for a design condition occurring once per year.

Typical design conditions

As explained previously, the typical coaster vessels in the SNS are most sensitive for T_2 values between 5.5-8s. Based on measured scatter diagrams (Figure 9), typical design conditions were identified. These are focussed on a good representation of the wave energy in the most relevant parts of the scatter diagram for added resistance of the example vessel. The associated wind speeds are based on the KNMI measurements. A duration of three hours is assumed for each condition. Assuming a JONSWAP spectrum seems suitable for this purpose.

- 10 times per year: H_s 5-6m, T_2 ~7s, v_w 20-31m/s
- Once per year: H_s 6-7m, T_2 ~7.5s, v_w

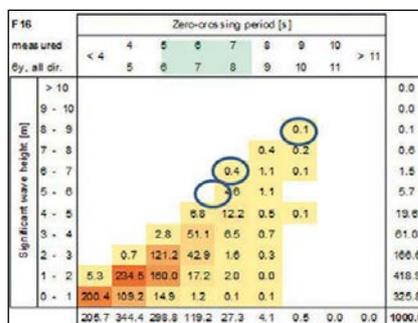


Figure 9: Scatter diagram for location F16, design conditions

25-38m/s

- Once per 10 years: H_s 8-9m, T_2 ~9.5s, v_w 28-31m/s.

Conclusion

Wave drift forces are frequency-dependent, so selecting an appropriate wave spectrum is important. The same is valid for the wind speed, as wind drift forces are proportional to its square. Specifically for the example vessel in the SNS, the following conclusions can be drawn based on the present study:

- The GKSS and ECMWF hindcast wave databases provide a more suitable reference than GWS and DNV for the considered area and purpose, as the latter include unrealistically steep waves.

- JONSWAP seems a valid spectral shape – the drift forces that were predicted are conservative and within around 15% accuracy for most cases, compared to the measured spectra.
- The directly measured wind speeds at locations F16 and J06 agree very well with the GKSS database. The MARIN approximation of wind speed works well for lower waves, but overestimates higher wind speeds (+20% for 25m/s wind). An update of the method seems recommended.
- Typical design conditions that lead to reliable drift force results for a typical coaster sailing in the SNS were identified.
- For the once-per-year design condition, the wave-added resistance contribution is around 30% of the total resistance, and the wind contribution around 5%. **NA**

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Tunnel vision

Newcastle University's Emerson Cavitation Tunnel has been refurbished and reinstalled as part of a £2.5 million project creating a marine campus at Blyth

Used throughout the marine sector for more than 50 years, the refurbishment assures the future of the tunnel for research and development.

The 300kW pumped system is able to test models up to 400mm in diameter at speeds of up to 10m/s (20 knots) including laser measurements of velocity profile. As well as high-speed video recording, cavitation and noise is able to be tested in uniform and non-uniform streams. The tunnel is also able to be used to test wake simulation.

Commissioned in 1950, the tunnel has enjoyed multiple upgrades and enhancements during its life including a previous refurbishment in 1980 that was prompted by demand for research into heavily-loaded propellers operating in non-uniform wakes.

But its future lies not just in propulsion experiments. Peter Bowes, technical manager for Newcastle University's Faculty of Science, Agriculture and Engineering says: "There is an increasing demand to use the tunnel to explore tidal and current turbines, and to investigate fowl-release coatings and next generation self-polishing coatings. Our vision has been to assure the next fifty years of operation and service to the marine sector."

Transported to Poland for refurbishment

by Gdansk-based CTO, the opportunity was taken to relocate the tunnel to the University's new marine campus within the Port of Blyth, which already included a 2015-built marine station comprising an operations office, workshops, aquarium and teaching facilities to support the University's £1.5 million research vessel, *The Princess Royal*.

The cavitation tunnel will continue to carry the name of Dr Arnold Emerson, its long-serving superintendent whose dedication and service to the facility was acknowledged following the 1980 refurbishment. Another name synonymous with the tunnel for many is that of George Mitchell, who recently celebrated 60 years of service to Newcastle University and the marine sector at the RINA AGM.

The purpose-built space for the cavitation tunnel is double the size of its previous home and provides a secure site for commercially sensitive and defence-related testing. Comprising 10tonnes handling capability, 800amp three-phase supply, a flume for timed studies of marine coating formation, a soon-to-be-installed slime farm, and flexible space for experiment-specific requirements, the expansion of the Blyth campus represents a major investment and commitment from Newcastle University to the marine sector in

the burgeoning hub of Port of Blyth.

Already home to the Offshore Renewable Energy Catapult, Blyth is an increasingly important hub of marine engineering. EDF Energy Renewables are underway constructing the Blyth Offshore Demonstrator wind farm 3km offshore, and Port of Blyth has partnered with Arch — the Northumberland County Council-owned development company — to create Energy Central, a platform for further developing the Port and town as an offshore energy base.

The refurbishment of the cavitation tunnel and expansion of the Blyth marine campus is the latest in a series of major achievements by Newcastle University in marine engineering and technology. In June, Newcastle launched its deep-sea research facility, Tyne Subsea: National Centre for Subsea and Offshore Engineering, in Wallsend. The School of Engineering has also won a number of research grants around its Sensors, Electromagnetic and Acoustics Laboratory (SEALAB) recently.

Dr Alan Murphy, reader in Maritime Engineering, said: "It's a very exciting time at Newcastle University and our new School of Engineering. In the Marine, Offshore and Subsea Technology group, we're opening up new opportunities for research, teaching and collaboration with many academic and commercial disciplines, as well as unlocking investment in facilities."

Prompted to consider recent marine-related investments and growth as an indication that the North East of England remains a hub for marine technology, Dr Murphy says: "Indeed it is. The North East ports are busy and diversifying. The growth of the region's role in the global offshore energy and transportation sectors is clear to see and Newcastle University will continue to be a major part of the international marine community." **NA**



The refurbished, relocated tunnel at its new home in Blyth

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By Chris Thomas

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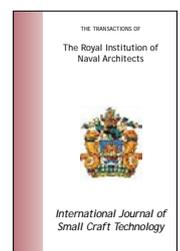
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www.pacific2017.com.au/international-maritime-conference

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International exhibition,
Mumbai, India
www.inmex-smm-india.com/en/home

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London, UK
www.rina.org.uk/Contract_Management_Course_Oct_2017

October 24-27, 2017

Kormarine

International exhibition, Bexco,
Busan, Korea
www.kormarine.net

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London, UK
www.rina.org.uk/EPD_2017

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International conference, Naples, Italy
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www.europort.nl

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www.rina.org.uk/Alternative-ship-power

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International conference,
Glasgow, Scotland
www.asranet.co.uk

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Indonesia 2017
Jakarta, Indonesia
www.rina.org.uk/ICSOT_Indonesia_2017

November 14-16, 2017

METSTRADE

International exhibition,
Amsterdam, Netherlands
www.metstrade.com/mets/exhibition-info/about-the-exhibition

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London, UK
www.rina.org.uk/Presidents_Invitations_Lecture_Dinner_2017

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www.rina.org.uk/LNG_LPG2017

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Workboat

International exhibition,
New Orleans, USA
www.workboatshow.com

December 4, 2017

International Workshop on Water-Jet Propulsion 2017

Shanghai, China
www.rina.org.uk/Water-Jet_Propulsion_2017

December 5-8, 2017

Marintec China

International exhibition,
Shanghai, China
www.marintecchina.com/en-us

December 7-8, 2017

International Conference on Ship & Offshore Technology (ICSOT) India 2017

Kharagpur, India
www.rina.org.uk/ICSOT_India_2017

December 18-20, 2017

Advances in Onshore & Offshore Wind Energy (AdWIND 2017)

International conference, Chennai, India
www.adwind2017.com

January 20-28, 2018

boot Düsseldorf

International exhibition, Düsseldorf,
Germany
www.boat-dusseldorf.com

January 23-24, 2018

Smart Ship Technology

International conference, London, UK
www.rina.org.uk/Smart_Ships2018

January 24-26, 2018

Vietship

International exhibition,
Hanoi, Vietnam
www.viet-exhibition.com.vn

February 21-22, 2018

Design and Operation of Ice Class Vessels

International conference, London, UK
www.rina.org.uk/Ice_Class2018

March 14-16, 2018

Asia Pacific Maritime (APM) 2018

International exhibition, Singapore
www.apmaritime.com

March 21-22, 2018

Eco-propellers – Research, Design, Construction & Application

International conference, London, UK
www.rina.org.uk/Eco-Propellers_2018

March 21-22, 2018

Shipping2030 Europe

International conference, Copenhagen
www.maritime.knect365.com/shipping2030-global/

April 11-13, 2018

Sea Japan 2018

International exhibition,
Tokyo, Japan
www.seajapan.ne.jp/en/

May 2-4, 2018

Danish Maritime Fair

International exhibition,
Copenhagen, Denmark
www.danishmaritimefair.dk

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www.turunmessukeskus.fi/en/event/navigate

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