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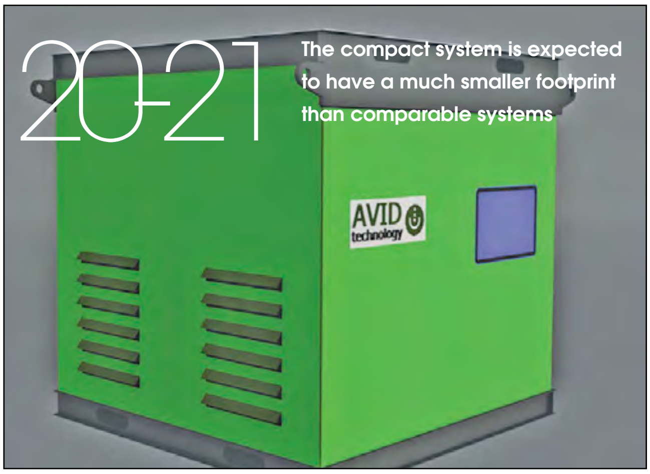

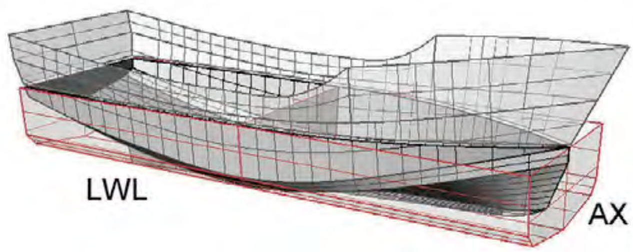

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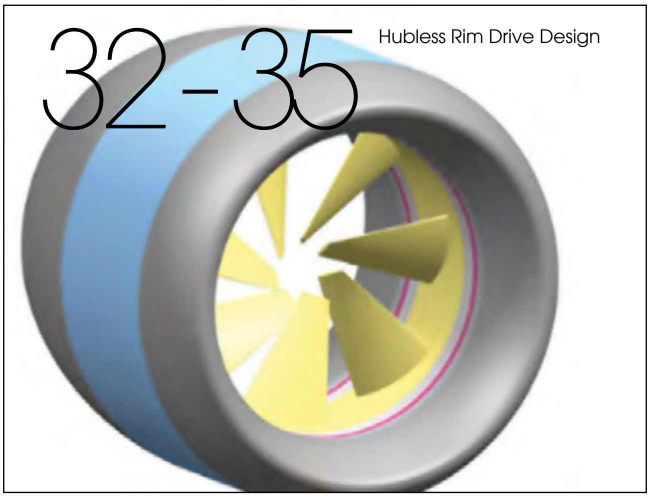

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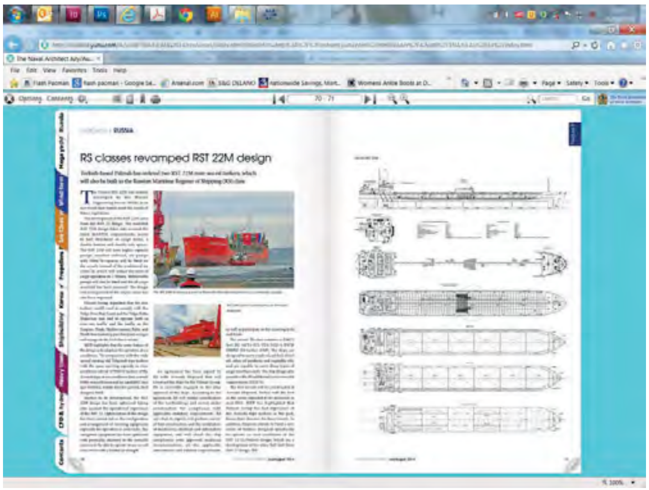


Don't feed the phish

The Be Cyber Aware at Sea campaign (www. becyberawareatsea.com) is not without wider relevance

The Petya cyber-attack in late June made global headlines as scores of major companies reported their IT systems had been infected. The ransomware was propagated via infected 'phishing' emails which, when the unsuspecting recipient opened, commandeered the boot records of Windows-based systems and demanded that users pay a US$300 ransom in order to regain access.

Among the high-profile victims was Maersk, which for several days was plunged into uncertainty as servers in Europe and India were forced offline, affecting "multiple sites and select business units", according to a statement on Maersk's Twitter account. Although most services and Maersk-operated terminals had returned to some semblance of normal working order within 24 hours, some, such as the recently-built Maasvlakte II terminal, were not restored to full operability until several days later.

Naturally, Maersk has divulged little about what happened or how it resolved these problems, although most major antivirus companies were able to provide updates to their software fairly quickly. What makes the Petya case particularly intriguing is that many security experts believe that the virus was not all that it seemed. Its payment system – which required victims to communicate via an address which was promptly suspended by the email provider – appeared almost amateurish. Ukrainian companies were among the earliest to report problems and some believe its true purpose to have been political, whether as a means of causing chaos or a 'test run' for something more serious in the future.

Ever since the pre-millennial tension which arose in anticipation of a 'Y2K bug', anxiety has grown about 'the big one', a cyberattack equivalent to a global pandemic which will cause catastrophic damage to IT infrastructure. Maritime is no exception to this and at June's meeting of IMO's Maritime Safety Committee a resolution on maritime cybersecurity risk management in safety management systems, was adopted with a requirement that cyber risks be "appropriately addressed" by an operating company's Document of Compliance no later than 1 July 2021.

Of course, this relates to vessels in service where a systems failure could have serious safety implications, potentially rendering the vessel inoperable. The consequences for a ship designer or builder are perhaps less grave, but the rising prominence of cloud-based collaborative and 'digital twin' platforms are not without opportunities for mischief. No press launch for these new services is complete without one of the attendant maritime journos raising the question of the system's security measures, which is usually met with a well-rehearsed response. But the level of encryption deployed on a given platform or service is quite another thing from the idiosyncrasies of human behaviour. A casually shared password or corrupted data stick can introduce vulnerabilities that are less easy to mitigate.

Computing facilitates and expedites and most of what's discussed in any given issue of *The Naval Architect* would now be inconceivable without it. Conversely, there are limitations and it's no substitute for the years of cumulative training, education and research that bring a project to its realisation. Intrinsic to that is the development of new methodologies that are fit for purpose, and in our CFD feature, HydroComp's Don McPherson explains how the evolutionary nature of ship design calls for a multi-order 'tool chain' approach to hydrodynamic analysis. The number crunching involved in 3D CFD analysis remains an onerous and time-consuming task and although McPherson writes with particular reference to the NavCad platform it contains some broadly applicable advice.

From design to realisation: advances in shipbuilding technology means the style and construction of tomorrow's vessels could be very different from traditional approaches. While 3D printing and robotised welding remain on the fringes (for now) they are harbingers of a greener, more cost-efficient future. It's a subject we'll be returning to in next month's issue with proposals to update composites manufacturing regulations. Another portent of things to come with the rise of electrically-driven vessels are rim-driven propulsors, which could obviate the need for mechanical drive trains. As ever with electric propulsion, the principal challenge remains that of generating the requisite power for larger vessels, but the solution, if or when it can be found, could offer over huge efficiency gains.

Visiting the Nor-Shipping trade show in Norway a few weeks ago, I was constantly reminded both of the esteem with which this title is held and how passionate those within the fields of ship design, research and technologies are about the work they're engaged in. It seems then a good opportunity to remind readers how vital your feedback is to maintaining the quality of this publication. If there's a subject you believe we're not giving sufficient attention please get in touch, particularly if it's a field you're directly involved in. Careless talk (and actions) may be costly when it comes to cybersecurity, but spreading the word needn't always be so detrimental. *NA*

Regulation

IMO delays ballast water compliance

IMO secretary general, Kitack Lim, proclaimed the 71st meeting of IMO's Marine Environment Protection Committee (MEPC) a "momentous session" in his closing remarks on 7 July.

In the most keenly anticipated item on the agenda, the delegates agreed upon what the IMO describes as a "practical and pragmatic" implementation for the Ballast Water Management (BWM) Convention. As previously agreed, enforcement of the D-2 ballast standard, which requires the installation of ballast treatment systems, will come into effect from 8 September for new ships.

But, in news which will come as a blow for ballast treatment manufacturers, for vessels already in service BWM will not be required before the first or second renewal survey (if the first renewal survey falls between 8 September 2017 and 8 September 2019). This means in some cases vessels will not need to have a treatment system installed until 8 September 2024.

Among other developments, the MEPC also agreed to scope of work required to achieve the 0.50% n/m global limit on sulphur content in marine fuel, which comes into effect from 1 January 2020. The North Sea and Baltic Sea will be designated as emission control areas (ECAs) for nitrogen oxides with effect from 1 January 2021.

The MEPC also adopted guidelines for the verification of ship fuel oil consumption data and the management of the IMO's Ship Fuel Oil Consumption Database. Delegates were informed that nearly 2,500 new ocean-going ships have been certified as complying with the Energy-Efficiency Design Index (EEDI) standards. However, under approved amendments the EEDI compliance for ro-ro's will be subject to a concept whereby EEDI reduction is relative to a 'reference line' of incrementally tightening standards.

Meanwhile, further work was undertaken to address shipping's greenhouse gas (GHG) emissions, with a view to the adoption of an initial IMO GHG strategy in 2018.

It was a particularly busy MEPC session at IMO Headquarters in London

Technology

Rolls-Royce in remotely - operated tug trials

Rolls-Royce has announced the first trials of a remotely-operated tug have taken place in Copenhagen harbour.

Working in collaboration with towage operator, Svitzer, and supported by Lloyd's Register, the captain of the 28m *Svitzer Hermod*, stationed at the remote base at Svitzer's headquarters, guided the vessel through a series of manoeuvres, including berthing alongside the quay, undocking, turning 360° and then being piloted to the Svitzer HQ.

Rolls-Royce and Svitzer say they have signed an agreement for the continued testing of remote and autonomous vessels. The primary systems involved will be autonomous navigation, situational awareness, remote control centre and communication. Rolls-Royce has previously said it expects to have an unmanned vessel in operation by the end of this decade.

Built in Turkey at the Sanmar yard in 2016 to a Robert Allan ship design, the *Svitzer Hermod* is equipped with a Rolls-Royce Dynamic Positioning System, which Roll-Royce says is the key link in its remote-controlled system. It also features a range of sensors that combine different data inputs to give the captain an enhanced understanding of the vessel and its surroundings (see "Ship Sight' envisages safer operations' in the March issue of *The Naval Architect*).

This data is transmitted securely to a Remote Operating Centre (ROC) from where control of the vessel is handled. Drawing upon insight from experienced masters, the ROC dispenses with the traditional wheelhouse design of the ship's bridge in favour of an intuitive layout to the various system components, which Rolls-Royce says creates a "future-proof standard" for remote operation.

Newbuildings

Disney announces new cruiseship

With already six ships to its name, Disney Cruise Line announced plans for a seventh vessel at Disney's D23 Expo in Anaheim, California, earlier this month. Plans to build two new ships were revealed last year and this newest addition to the fleet will be built at the same shipyard, Meyer Werft shipyard in Germany, with a scheduled completion date of 2022.

Chairman of Walt Disney Parks and Resorts, Bob Chapek, says: "We decided two ships wouldn't be enough to hold all of the exciting new experiences we have been dreaming up to take family cruise vacations to a whole new level with immersive Disney storytelling, world-class family entertainment, and imaginative innovations that are

fantastically fun and uniquely Disney. By the time all three new ships are sailing, we'll have nearly doubled the size of our existing fleet."

Initial designs are still in development, but all three new ships will be LNG-powered and approximately 135,000gt in size, with 1,250 guest staterooms planned for each.

Since Disney Cruise Line's launch in 1998, the company has given the cruiseship industry lots of firsts, including virtual 'Magical Portholes' in interior staterooms and the first water coaster at sea.

Regulation

Is EEDI a hinderance to design efficiency?

Over-compliance with the IMO's Energy Efficiency Design Index (EEDI) is actually doing more harm than good, according to a report published in July by non-governmental organisation Transport & Environment.

Introduced in 2015, the EEDI is intended to set a rising bar for efficiency standards. With effect from that year, vessels were expected to be least 10% more efficient (Phase 1), with stringency increasing to 20% in 2020 (Phase 2) and 25% by 2025 (Phase 3).

The report entitled *Estimated Index Values of Ships 2009-2016* analysed the development of ships which entered the global fleet during that period. Using a simplified version of the EEDI called the Estimated Index Value (EIV), which draws upon publicly available information, it was found that overall the average design efficiency of new ships has improved.

However, in 2016 the efficiency of new bulkers, tanker and gas carriers was actually worse than 2015, when the EEDI was first introduced. Moreover, the number of vessels meeting the Phase 1-3 standards had decreased in 2016.

The report found that among ships built in recent years, at least 20% have an efficiency that is more than 20% within EEDI requirements, with that number significantly increasing for general cargo and container ships.

It also noted that "a surprisingly large share of ships that entered the fleet in 2016 had an EIV that is well above the reference line, sometimes more than 50%."

"This suggests that a large variation in design efficiency that is not determined by ship type-specific requirements," the report concluded.

Digitalisation

Rolls-Royce, DNV GL join forces for digital platform

Rolls-Royce, the Norwegian University of Technology Science (NTNU), research organisation SINTEF Ocean, and class DNV GL have signed a Memorandum of Understanding (MoU) to develop an open source 'digital twin' platform, it was announced in July.

A concept which is gaining traction across the maritime sector (see p.42), the 'digital twin' creates a digital version of the real ship and allows any aspect of it to be scrutinised via a digital interface. It can be applied both during design and construction of the vessel and throughout its lifecycle for performance and safety inspections.

According to Asbjørn Skaro, director digital & systems, Rolls-Royce the concept will "form the basis for novel ways of designing, constructing, verifying and operating new maritime concepts and technology."

Remi Eriksen, Group President and CEO, DNV GL adds: "We are entering a new era with the accelerated uptake of more IT-technology in shipping. Digitalisation of information flows will have a positive impact on safety and environmental performance... A platform like this could form the basis for future class services."

Earlier this year, DNV GL launched its Veracity 'big data' service and said that R&D work on developing a digital twin platform was ongoing. Other class societies such as Bureau Veritas have also announced ongoing work in this area.

The project partners say they will make the platform available for use by other parties with a view to designers, equipment and system manufacturers, shipyards, research institutes and shipowners being able to work and innovate together. Projects may either be made generally available or restricted to select partners and the idea is that the platform can also serve as a 'model library' for different ship concepts.

The partners are now forming a steering group that will define and govern the system's development and its eventual deployment.

Newbuildings

DFDS places ro-ro orders

DFDS has placed an order for two ro-ro vessels with China's Jingling shipyard.

It is a repeat of an order the Copenhagen-headquartered operator placed for two identical vessels with Jingling last year, with a 6,700 lane metre load capacity and space for 450 trailers. The vessels will enter service from 2019 and 2020.

Designed by naval architects Knud E. Hansen, the vessels are the first to be built to IMO's EEDI standards and said to cut energy and emissions by more than 25%. The vessels will be fitted with scrubbers, ballast water treatment systems and a number of energy-saving technologies.

To speed up loading and unloading, the ships will also be equipped with a unique ramp system with three independent stern ramps and internal ramps on each side in the ships. *NA*

IMO scopes out unmanned ships

While there were a number of hotly-debated issues on the agenda for the 98th session of IMO's Maritime Safety Committee (MSC), arguably the most interesting was that of unmanned ships or, as the IMO prefers to refer to them, Maritime Autonomous Surface Ships (MASS), writes *Malcolm Latarche*.

Classification societies such as LR and DNV GL have already published studies and defined varying degrees of autonomy for ships covering intermediate stages between fully-manned and unmanned vessels. The idea has already moved beyond the conceptual stage with Rolls Royce having demonstrated a tug being operated remotely from shore (see p.10) and Kongsberg and DNV GL beginning a project that will result in what is being claimed as the world's first unmanned vessel undergoing trials in Norwegian waters. Even China has got in on the act with China Classification Society and HNA Technology Logistics Group joining with others including DNV GL and ABS, to launch the unmanned cargo ship development alliance.

The regulatory issues around autonomous ships have been widely discussed away from the IMO, which has now accepted that the subject must feature more prominently on its own agenda. At MSC 98, two papers were circulated on the subject, one a joint submission by Denmark, Estonia, Finland, Japan, the Netherlands, Norway, the Republic of Korea, the United Kingdom and the United States, and another from the International Transport Workers Federation (ITF).

The MSC accepted the first paper and agreed to include the issue of autonomous ships on its agenda by way of a scoping exercise to determine how the safe, secure and environmentally-sound operation of such vessels may be introduced in IMO instruments. The scoping exercise is seen as a starting point and is expected to touch on an extensive range of operational considerations. It will also address different levels of automation, including semi-autonomous and unmanned ships and could include discussion of a definition of what is meant by an 'autonomous ship'.

The ITF paper raised the important issue of the qualification of remote operators and it was suggested that the exercise should include scoping of the full range of human element factors proposed, conducting a Formal Safety Assessment or gap analysis as to the safety, technical, human-element and operational aspects of autonomous remotely-controlled or unmanned ships.

The MSC also agreed that proper consideration should be given to legal aspects, including where the responsibility would lie in case of an accident involving a MASS. As things stand, it is expected that the scoping exercise will take place over four MSC sessions, through to mid-2020.

There was plenty more to discuss including cyber security and a resolution is to be issued reminding flag states, owners and ROs that such matters, especially where they may impact on vessel safety, should be covered by an operator's safety management system. The resolution encourages flag states to ensure that cyber risks are appropriately addressed in safety management systems no later than the first annual verification of the company's Document of Compliance after 1 January 2021.

MSC approved the report from the Ship Design and Construction sub-committee (SDC 4), extending the target completion for work on guidelines on stability computers and shore-based support for existing passenger ships to 2018. It also approved Interim guidelines for use of Fibre Reinforced Plastic (FRP) elements within structures.

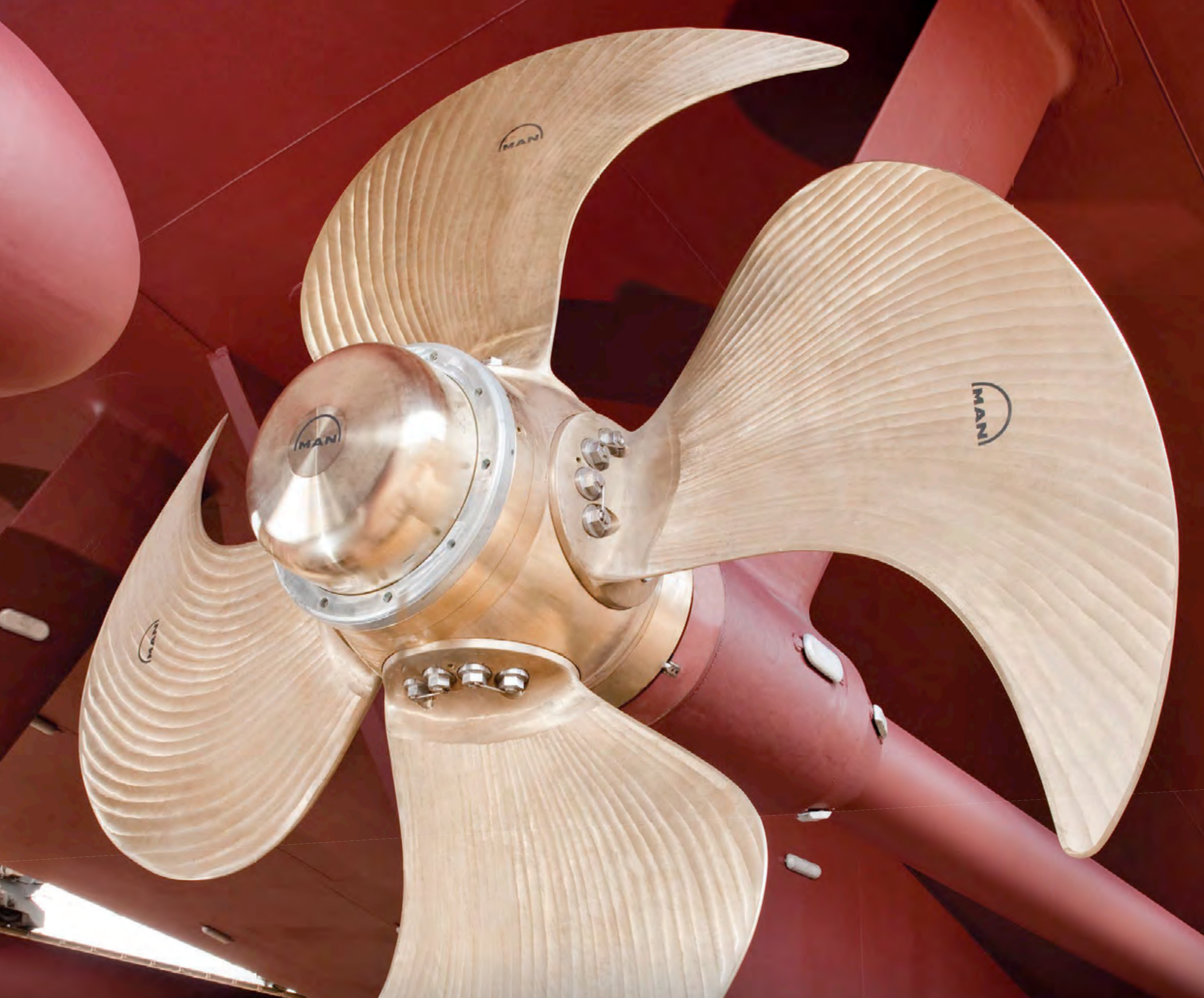
On the question of passenger ship safety and following on from the *Costa Concordia* incident, the meeting adopted a set of amendments to SOLAS chapter II-1, relating to subdivision and damage stability and approved the revised guidance for watertight doors on passenger ships which may be opened during navigation.

A number of other amendments to SOLAS Chapter II were adopted including a definition of a vehicle carrier and fire safety requirements for cargo spaces containing vehicles with fuel in their tanks for their own propulsion, specifically vehicles which do not use their own propulsion within the cargo space. Clarification on the requirements for fire integrity of windows on small passenger vessels and special purpose ships was also given.

All of the above amendments, along with operational aspects of vessels such as requirements for damage control drills on passenger vessels, testing of lifesaving appliances, and amendments to the IMSBC Code and the HSC Codes of 1994 and 2008, have an expected entry into force of 1 January 2020.

On the matter of goal-based standards (GBS), the meeting confirmed that the non-conformities identified in the initial verification audit of ship construction rules for oil tankers and bulk carriers had been rectified. As a consequence, amendments to the GBS Verification Guidelines and an updated timetable and schedule of activities were agreed.

Part A of the Verification Guidelines is now complete so work should concentrate on unresolved issues as well as completing the Part B draft guidelines in time for MSC 99 next May when new proposals should also be submitted. The final draft of the Guidelines would then be ready for submission to MSC 100 in December 2018. *NA*



Propulsion

Wärtsilä waterjets to power Danish high-speed ferry

Wärtsilä has won a contract to supply its compact axial flow jet solution for a high-speed RoPax ferry currently under construction in Australia.

The Finnish-headquartered manufacturer will supply four of its waterjets plus the hydraulics and control system for a new 109m LOA high-speed RoPax being built at the Austal Ships Pty yard in Australia for Molslinjen A/S of Denmark.

In a statement, Wärtsilä's said that its compact axial flow jet solution was considered the most appropriate choice for this vessel, as it offered the customer optimal weight and performance criteria for the ship's mission profile.

Wärtsilä modular waterjets

"This is a prestigious newbuild project and we are proud that our waterjets have been selected to drive this high-speed ferry. The proven design and reliable performance of the Wärtsilä solution were deciding factors in the winning of this contract," says Arto Lehtinen, vice president - propulsion, Wärtsilä Marine Solutions.

Wärtsilä says that unlike a non-axial design, the compact axial waterjet does not expand in a radial direction downstream. The water flow is directed through the pump along the most efficient path, offering an average 25% reduction in transom occupancy.

The first-in-class vessel will be the first built by Austal to feature two full vehicle decks for 425 cars, or 610 lane metres for trucks and up to 232 cars and capacity for up to 1,006 passengers.

Upon delivery, the vessel is contracted to operate on the crossing of the Kattegat between Aarhus and Odden. It is scheduled for delivery during the fourth quarter of 2018, with the Wärtsilä equipment expected by May 2018.

www.wartsila.com

Performance monitoring

NAPA launches AIS-based fleet monitoring tool

Not content with its position as an industry leader in 3D ship design software, not to mention loading computers and data-collecting solutions, NAPA used the Nor-Shipping exhibition in June to launch a new cloud-based web service utilising AIS data: NAPA Fleet Intelligence.

The subscription service is said to offer ship owners and operators a simple, affordable and accurate efficiency data with zero installation or disruption to operations.

"The new service analyses the ship's operational performance based on publicly available data and our own algorithms. AIS is nothing new but over the last two years there have been a lot of satellites launched and coverage is much better.

"So we decided to combine this AIS data with existing information we have about the ship designs and the from the data collecting solutions we've been offering for the last 10 years," explains Pekka Pakkanen, director of development for NAPA Shipping Solutions tells *The Naval Architect*.

"To know the operational performance we don't need expensive equipment on board the vessel. It's possible to get it from simulation models and publicly-available data. We are analysing many parts of operational efficiency and regulatory changes can and will be added."

Pakkanen adds that the service works by splitting operational data into voyages and then applying verified simulation models. By cross-referencing with AIS data – which covers around 55,000 vessels – and information from weather monitoring services it will be possible to provide voyage-by-voyage analysis of fuel consumption for any conventionally powered vessel dating back as far as January 2015.

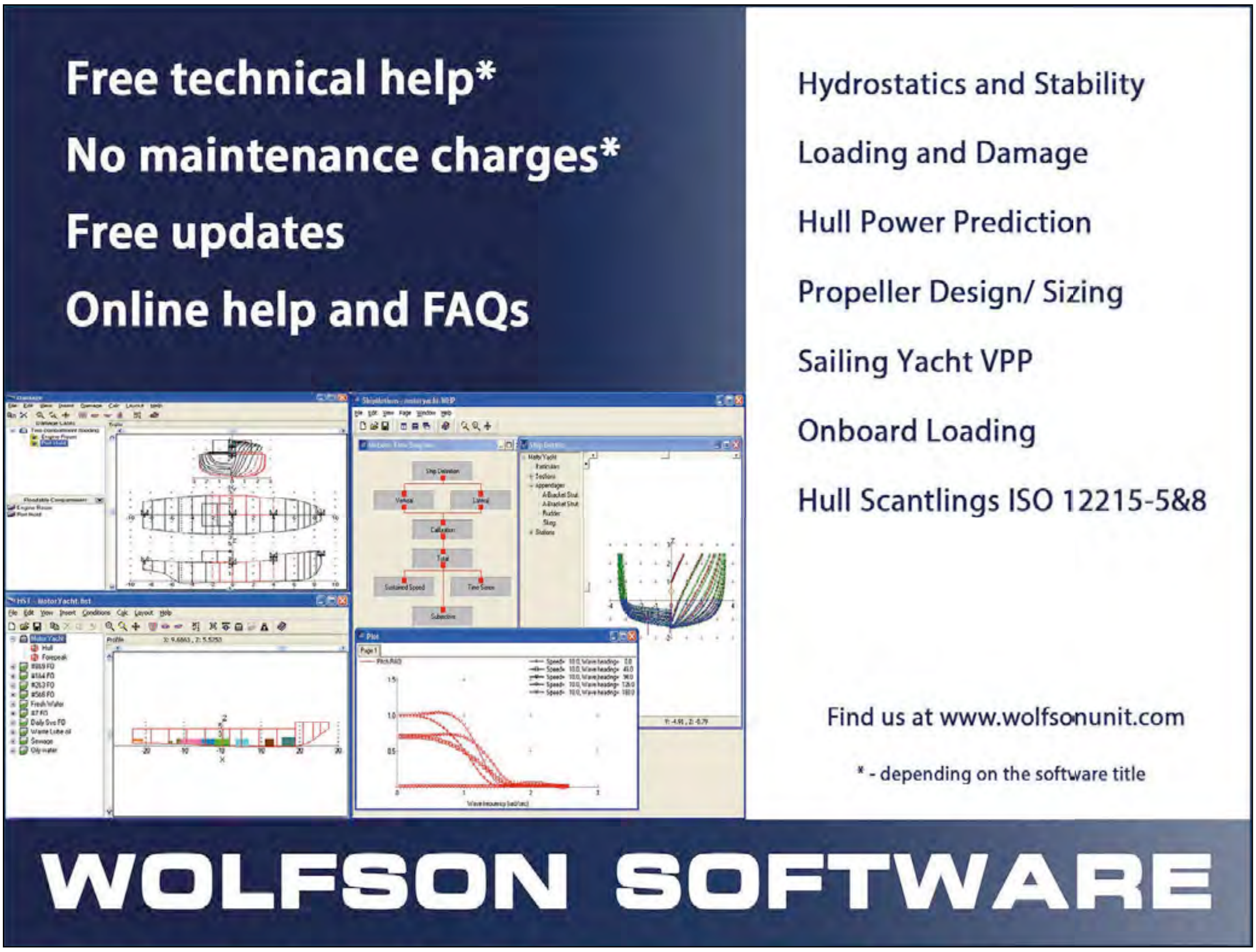
www.napa.fi

Rudders

Van der Velden to supply rudders for COSCO

Dutch company, Van der Velden Marine Systems, has been chosen to supply rudders for five 20,000 TEU mega containerships, ordered by China COSCO Shipping Corporation Ltd. The high-efficiency rudders will be delivered to Dalian Shipbuilding Industry Co. (DSIC) and Shanghai Waigaoqiao Shipbuilding this year, with the vessels due to launch in 2018.

Van der Velden will be providing its largest Atlantic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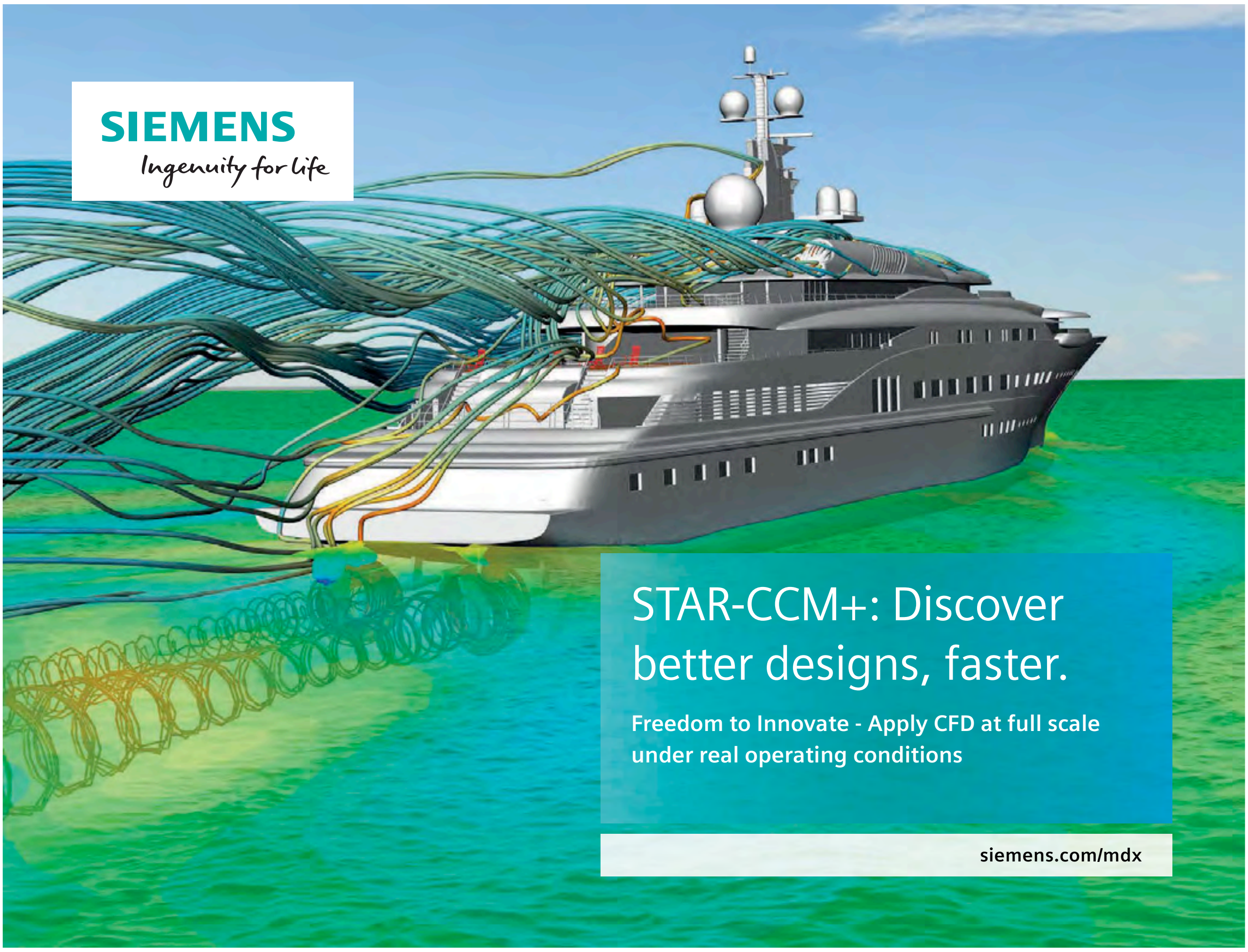
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rudders, complete with asymmetric rudder technology (ART) and weighing over 250tonnes each. The rudders have been specially designed to ensure accurate course-keeping, manoeuvrability and to keep cavitation to a minimum when travelling at high speed. They will also be easy to dismount when repairs or inspections are required and the water-lubricated synthetic bearings require little maintenance.

Wim Knoester, managing director at Van der Velden, is excited by the partnership: "With these contracts, we are pleased to say that we have strengthened our position in the Chinese market."

This isn't the only advance into the Asian naval market for Van der Velden this year – the company has also recently opened an office in Tokyo, Japan. The company is already supplying manoeuvring equipment to shipyards in China, South Korea, India and Taiwan.

www.vdvelden.com

Engines

WinGD's new engine passes FAT and TAT

Winterthur Gas & Diesel's (WinGD) newest addition to the Generation X low-speed diesel engine range, the X52, is already attracting attention, having successfully passed both its Factory Acceptance Test (FAT) and Type Approval Test (TAT).

The five-cylinder X52 engine, with a contracted output of 6408kW at 99 rpm and IMO Tier II emissions compliance, was tested at Hundong Heavy Machinery Co., Ltd. (HHM) in Shanghai, a WinGD licensee and, like WinGD, a part of the China State Shipbuilding Corporation (CSSC).

The much-anticipated news is a welcome development for WinGD, as the company has already taken orders for 14 X52 engines, including the test engine. Alexander Brückl, senior project manager - new engines at WinGD, says: "This very rapid market acceptance is based on the reliability and performance the Generation X diesel and dual-fuel engines have exhibited in service to date. This is also reflected in the fact that we have had the confidence to perform the TAT on the very first engine rather than a later engine, as the classification societies allow."

The WinGD 5-X52 diesel undergoing its FAT and TAT at the works of Hudong Heavy Machinery in Shanghai.

WinGD's Generation X engines not only offer reduced fuel consumption thanks to longer stroke configuration, but also have a relatively light structure and low maintenance costs. The latest model has a larger bore diameter compared with other WinGD engines, but as Brückl explains, "the bore-to-stroke ratio selected by WinGD is proving to be very popular."

The 5X52 test engine will now be delivered to Guangzhou in China, where it will power a 38,000 DWT bulk carrier, currently under construction at the Guangzhou Wenchong Shipyard, with the vessel due to join the CSSC fleet once built. The remaining 13 engines on the orderbook will all be six-cylinder 6X52s and built in Korea, with six of the engines, rated 7,180kW at 86.9rpm, set to power six 49,000 DWT petroleum products tankers.

www.wingd.com

Performance monitoring

Eniram unveils Skylight 2.0

Eniram, a subsidiary of Wärtsilä, has launched an upgrade to its predictive analysis tool Skylight just nine months after the inaugural version went to market.

Described as 'Fitbit for a ship' the Eniram Skylight 2.0 – a subscription service consisting of a transponder, data traffic, reporting and software interface – adds nautical maps, weather layers and route importation. Data about the ship's movements is collected every five minutes and relayed by satellite connection to Eniram's data centre. This information, combined with the vessel's noon reports, is combined and enriched with meteorological data, sea state and currents to model the vessel's speed and fuel performance

The upgraded system can also visualise a vessel's route from economic, safety and environmental perspectives and will also help operators with the reporting of emissions data in compliance with the EU's Monitoring, Reporting, Verification (MRV) requirements for CO_2, which become effective from the end of August.

The company says it is already well into development of Skylight 3.0, with launch expected at the end of this year. It also has a number of patents pending for its technology such as its Virtual Speed Log, with a view to third-party licensing.

www.eniram.fi

Mapping the road to worldwide electrification

The number of electric and hybrid-electric vessels is on the up, especially in Northern Europe, but is there a global trend to speak of? *The Naval Architect* reports

Scandinavia dominates the market when it comes to electrification of ships, but other regions may come to follow suit providing the right drivers are established, says Willie Wågen, global VP sales & marketing & MD Europe at Corvus Energy.

Wågen, while delivering a presentation on this topic at NOR-Shipping in June, expressed that many factors beyond simply cost are underpinning and driving ESS adoption across the globe. These include:

1. Technical drivers: Energy density, cost and performance attributes
2. Operational drivers: The number of use cases handled by ESS (e.g. load levelling, peak shaving and backup power) and high utilisation requirements (e.g. number of containers shipped, passengers carried etc.)
3. Economic drivers: Fuel prices and grid electricity prices
4. Regulatory drivers: environmental regulation, GHG tax incentives and government subsidies (as seen in Norway with its NOx fund and ongoing efforts to address CO_2 emissions in a similar fashion)
5. Societal drivers: Green consumer preferences and 'voting with their wallets'

It is no wonder that Scandinavia is at the epicentre of the electrification of shipping so far, highlighted Wågen, as the region encourages innovation and excellence in ship design. There is a high concentration of ferries and offshore vessels (which currently dominate the electrified fleet), high fuel prices that push alternative fuels, low electricity prices as "industrial electrical rates in Norway are the lowest in the world", strong societal pressure for green regulations, and strong regulatory incentives.

However, while this is the course of development for Scandinavia and other parts of Northern Europe, such as the UK and The Netherlands, which both possess most of the drivers presented above, there are wider patterns of development that suggest ESS adoption will spread to the rest of Europe, Asia and North America according to Wågen.

Corvus Energy's Willie Wågen

For the rest of Europe, economic, regulatory and societal conditions are in a good state to encourage ESS adoption and the proliferation of the electrified fleet. Fuel prices are high while electricity prices are medium to high. IMO emission control areas (ECAs) have been established and there are numerous clean energy subsidies or funding opportunities such as the EU's Horizon 2020 fund that can push green developments at the behest of high societal pressures.

In Asia, China is perhaps the best positioned region for ESS adoption. Fuel prices are moderate while electricity prices are low and the national government has created its own ECAs due to its motivation to address pollution levels, notably the problem of inner-city smog. Adoption of ESS in Japan and South Korea is still positive, but not to the same extent as in China. Fuel prices and electricity prices are moderately expensive and vessel and port emission regulations are unclear, says Wågen, making development less attractive. However, he adds, both nations have ambitions to be leaders in clean energy and their pedigree as shipbuilders works in the favour of innovations such as ESS.

In the case of North America, positive forces for adoption include low to medium fuel prices, low electricity prices and IMO ECAs. However, the major drawback in this market lies with consumers who are unwilling to pay for greener developments and a government response to emissions that is quite limited.

Despite the limiting factors for each of the regions discussed, there certainly seems potential for expansion of the ESS technology as nations move to reduce shipping emissions.

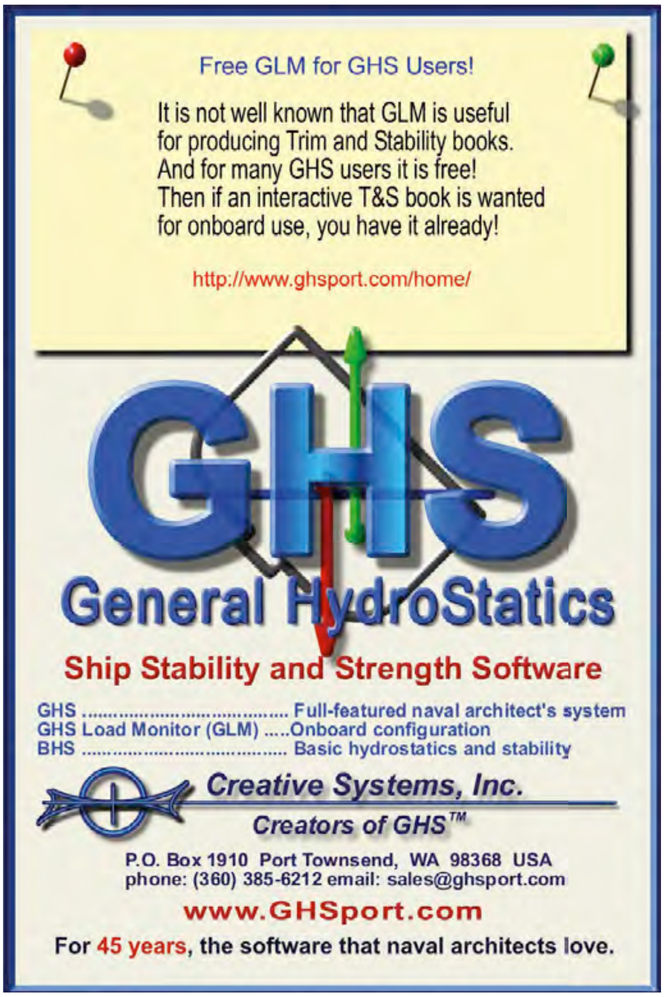
Classification society Bureau Veritas (BV) pays heed to this notion with the recent issuing of a new chapter specifically for electric and hybrid power solutions in its rules. This addition sees a new series of notations and rules that aim to support ship operators with the setting of requirements for energy storage systems.

BV expects that these new notations will encourage wider uptake of energy storage systems, facilitating a move beyond the cruise and ferry sectors, which have led developments in the field thus far.

"Obvious candidates for ESS are cruiseships with high hotel loads when in port, ferries with regular port visits and tugs with heavy peak load requirements," says Martial Claudepierre, business development manager, BV. He adds, "Ships with relatively short voyages making regular port calls could plug into local power enabling access to electricity from renewable source as well."

Whether such developments will substantially spread beyond Scandinavia is yet to be seen, but the delivery of two new LNG/electric hybrid ferries to Canada-based ferry company Seaspan, including *Seaspan Swift* (see *Significant Ships of 2016*), indicates some level of fulfilment in North America.

Claudepierre believes: "We will see more of these hybrid solutions ordered and our new rules and notations will help ensure that these systems can be designed and operated safely and efficiently." *NA*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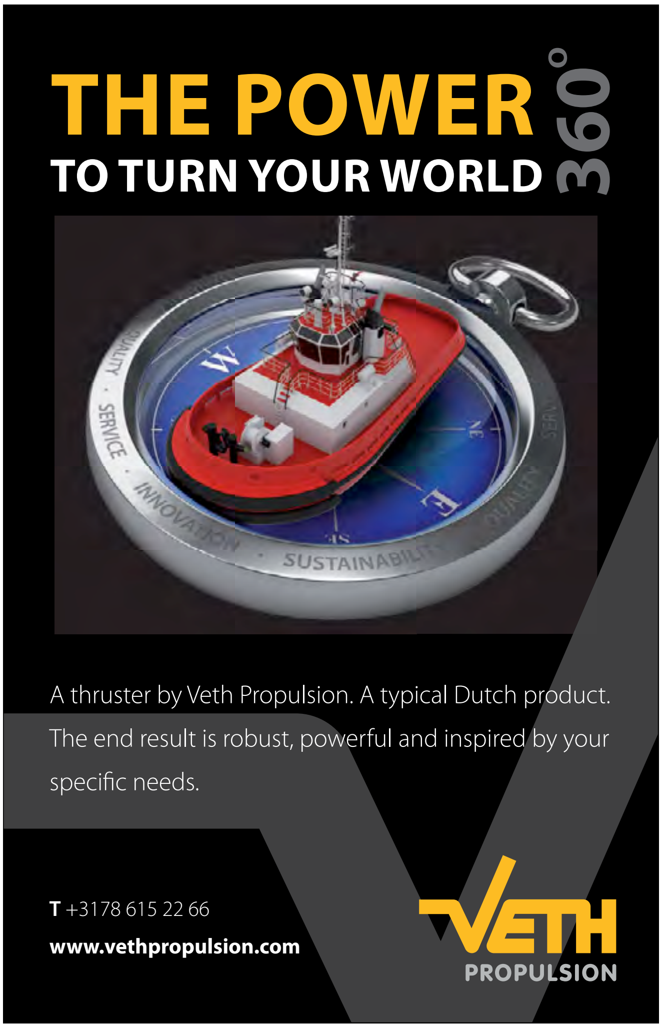
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Cross-pollination promises waste heat recovery upgrade

Developments in onboard waste heat recovery are about to be repackaged with the help of experience from the automotive industry. UK-based electrified powertrain and advanced thermal management system specialist, AVID Technology, aims to offer fuel savings of up to 8% in a more compact package for vessels

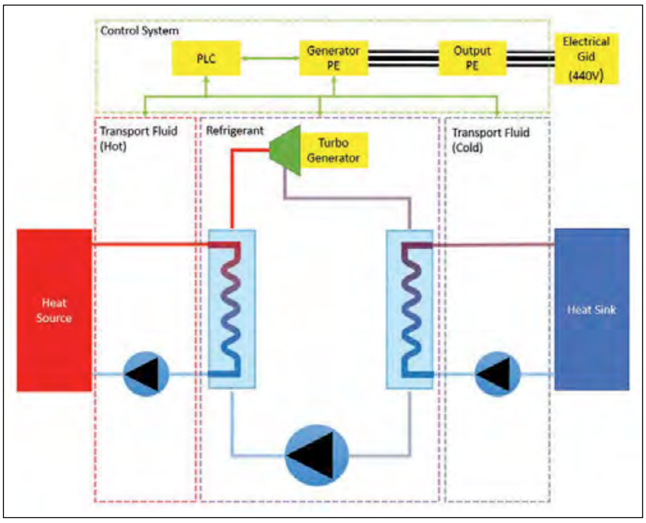
A £3.6m (US$4.7m) project funded by the Energy Technologies Institute (ETI) and led by AVID Technology is seeking to reduce emissions and vessel operating costs through the conversion of waste heat from a vessel's engine jacket water into electricity. The two-year project will partner AVID with Royston Power, France-based Enogia S.A.S. and RED Engineering, who will provide support and input, as the technology concept is brought to realisation, for the marine industry.

"The system uses the Organic Rankine Cycle (ORC), [which] means that an environmentally safe refrigerant is boiled with waste heat. This refrigerant steam is then used to drive a turbine which drives a generator. The refrigerant is then cooled and pumped back around the system," explains Ryan Maughan, founder and managing director of AVID Technology.

"While this type of technology has been available for some time and is similar to Organic Rankine Cycle systems developed by Calnetix and Climeon, the AVID system draws on technology and expertise developed for the automotive industry", says Joe Orrell, managing director at RED Engineering, "deploying a unique turbo generator power conversion system from AVID."

Maughan concurs, stating: "The ORC technology is fairly common, but what is new is AVID's high power density generator and electronics which have enabled the company to package a system into a much smaller volume than traditional ORC systems.

"AVID has also used its heavy-duty automotive background to take costs out and increase durability – the result is a system with a lower cost per installed kW than anything on the market, in a package size that is very well suited to the tight constraints of the marine application."



Circuit diagram for AVID Technology-led project's waste heat recovery system

The exact size of the system is yet to be confirmed, but "the AVID ORC system is very compact and therefore possible to package into a much wider range of vessels," according to Maughan. RED Engineering's Orrell adds that the system "will be packaged to fit into a vessel engine room as a retrospective installation," which gives some indication of its size and impact on vessel layouts. With this in mind, the system is being designed to be modular in order to meet the demands of the retrofit market. Such a design will allow it to be easily broken down and transported through tight hatches and access doors, although Maughan points out that "re-assembling and installing inside the vessel is bound to throw up some interesting challenges to overcome" as the project moves closer to completion.

The system's estimated 8% fuel saving derives from the ETI and a market study that the organisation conducted. "Our target is a particular level of power generation from the waste heat," says Maughan, but adds that "Multiple systems can be connected together to generate more power, and this in turn would result in a fuel saving that is dependent on how many systems you install vs. engine power on the vessel."

RED Engineering will assist AVID as it seeks to ensure the system meets SOLAS requirements and the class regulation of DNV GL. This will involve leveraging its expertise in safety critical marine systems engineering and working on the documentation and design rules which will allow the technology to be realised for marine applications.

The project's remaining members, Royston Power and Enogia S.A.S., will also play important roles. Royston will be responsible for working with vessel operators to identify any installation issues, to install the systems, and carry out in-vessel testing and commissioning, while Enogia will be responsible for the design of the system's ORC turbine.

The system is being developed with all types of vessels in mind, although at this point the project members are working with operators of more typical vessels such as bulk carriers and ferries. Maughan reasons that while a lot of interest has been received from the cruise industry where the benefits of such technologies are readily apparent, the segment does not represent the bulk of the world fleet and so the first demonstration units will not be installed on cruiseships. He says: "We have elected to work on more traditional vessels to demonstrate the potential for the technology in the mass market of marine vessels." Discussions are taking place to deliver a vessel demonstration unit in 2018.

The project has moved quickly through initiation and concept phases based on the background experience of AVID and Enogia in waste heat recovery technology and high-power density electronics and generator design, according to Maughan, but a price for the system has not yet been confirmed.

At present, the testing and approval of key components is taking place as well as design and development of the turbo generator, system packaging, and the seeking of design approval from DNV GL.

The compact system is expected to have a much smaller footprint than comparable systems

"The system is currently in a land-based development and testing phase and we are going through the design process necessary to make the technology marine-ready and obtain class approvals," says Maughan. "We anticipate challenges ahead in finalising the class approval and then when we [will] move to installing [it] in an actual vessel."

The next phase will see land-based testing of the marine specification system at full power, "a land mark achievement for the programme" concludes Maughan. *NA*

船舶经济贸易
SHIP ECONOMY & TRADE

China's shipbuilding industry still faces challenges

Completed tonnage from Chinese shipbuilders continued to show growth between January and May 2017. However, the orderbook has shown a year-on-year fall and a decline in the main economic indicators from major companies indicates a slowdown, according to the statistics from China Association of National Shipbuilding Industry (CANSI).

It means that China's shipbuilding industry still faces a rather severe challenge. However, CANSI's China Shipbuilding Capacity Utilization Index (CCI) suggests that China's shipbuilding capacity utilisation rate has actually been gradually increasing since the end of last year.

From January to May, the national shipbuilding completion stood at 22.93m dwt, an increase of 78.8% year-on-year; new Chinese orders had reached 9.86m dwt, down 31.5% and, as of the end of May, the orderbook was 85.15m dwt, down 30.7% from last May and a fall of 14.5% from the end of 2016.

In the same period, for exported vessels, the completion tonnage was 21.57m dwt, an increase of 82.2% year-on-year; new orders had reached 8.83m dwt, down 35% and, at the end of May, the on-book orders were 78.85m dwt, down 32.4% from last May. Export ships accounted for 94.1%, 89.6% and 92.6% of the national total in completion, new orders and orderbook, respectively.

One up, two down

From January to May, 53 key shipyards under monitoring completed 19.57m dwt, up 63.5% year-on-year whereas their new ship orders were 8.74m dwt, down 37% and, at the end of May, their on-book orders were 80.61m dwt, down 31.6% year-on-year.

From January to May, the same 53 shipyards completed export ships totalling 18.59m dwt, up 67% year-on-year, whereas their new export ship orders were 7.87m dwt, down 40.3% and, at the end of May, the orderbook was 74.97m dwt, down 33.7% year-on-year. Export ships account for 95%, 90.1% and 93% of the total for these shipyards in completion, new orders and on-book orders, respectively.

From January to May, industrial output from the 80 key enterprises in shipbuilding sector under monitoring fell 7.7% year-on-year. Among them, the

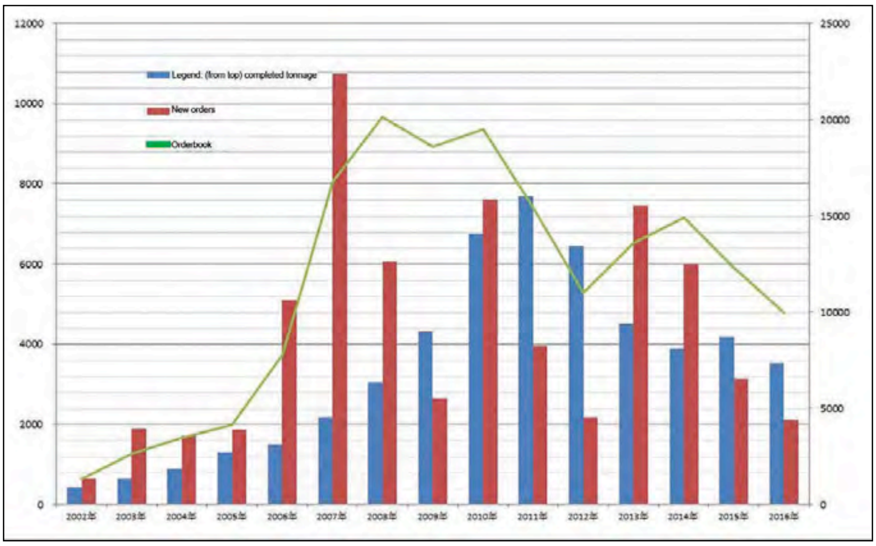
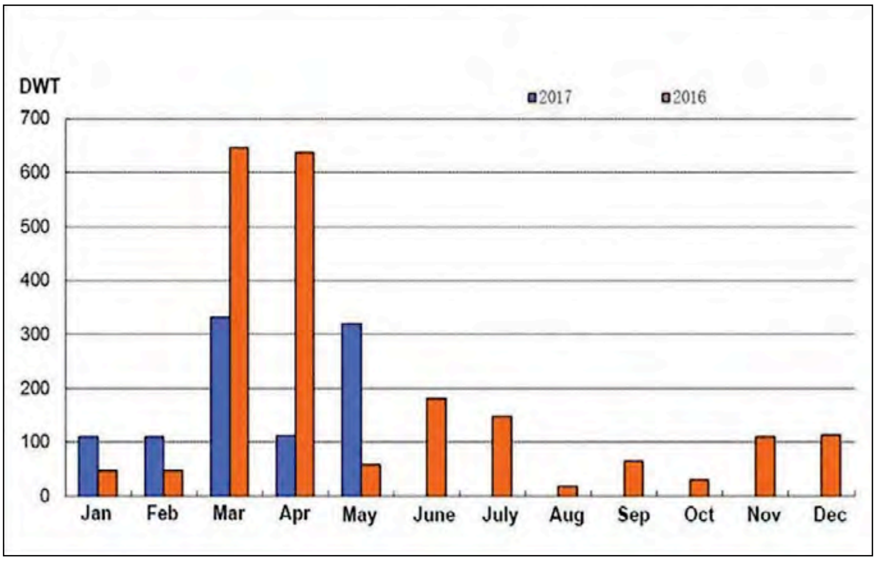


Figure 1 Three main indicators of China shipbuilding from 2002 to 2016

Figure 2 China new shipbuilding orders Jan- May 2017



shipbuilding output fell 11.6%, supporting service output fell 19.4% and shiprepair output fell 1.2%.

During the same period, the ship export output from the 80 key enterprises in shipbuilding sector under monitoring fell 10.8% year-on-year. Among them, the shipbuilding output fell 12.1%, supporting service output fell 20.6% and shiprepair output fell 4%. Their core business turnover fell 7.2% year-on-year and total profits dropped by 6.3%.

Increases in capacity utilisation

At the end of 2016, CANSI released its China Shipbuilding Capacity Utilisation Index (CCI). This is the primary index released by China's shipbuilding industry to reflect the extent of China shipbuilding capacity utilisation and to forecast future industry trends.

In the third quarter of 2016, CCI was at 607 points. According to the latest data released by CANSI in early April this year, CCI in the first quarter of 2017 was at 670 points, a 61 point increase (or 10%) quarterly growth, compared to 609 points in the fourth quarter of 2016. The index shows some signs of stabilising, but it is still in the cooling state.

The analysis of CANSI shows that, in the first quarter for 2017, due to the influence of the continued warming up in the shipping market, the capacity utilisation of the major shipbuilding enterprises continued to rise and shipbuilding completion saw a large increase, thus the index rose markedly.

CANSI expects that, in the second quarter of 2017, it will be difficult for the fleet and shipbuilding overcapacity situation to improve significantly. Conditions will make it tough for the market to continue to rebound, thus a challenge for any significant improvement in business, and the orderbook will continue to decline. Therefore, the China Shipbuilding Capacity Utilisation Index will be comparable with that of the first quarter and the overall trend will remain in a cooling state. *NA*

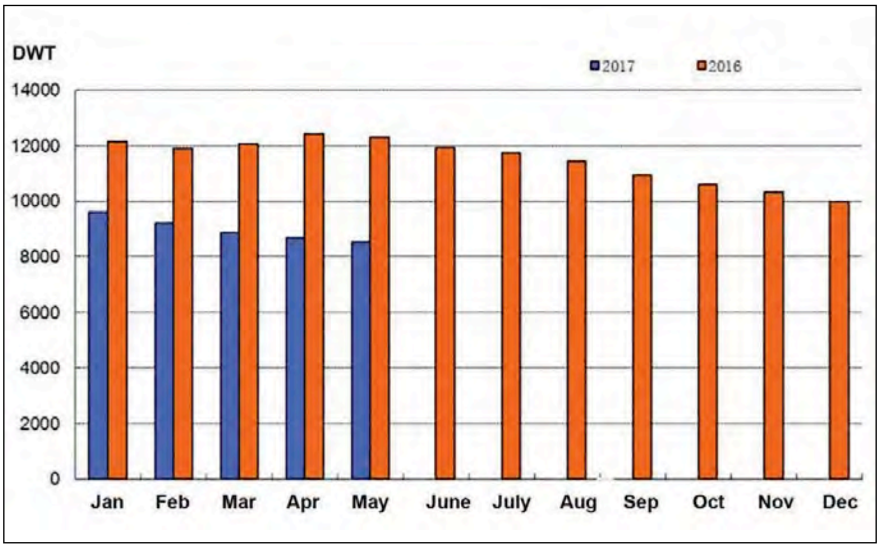


Figure 3 China orderbook Jan-May 2017

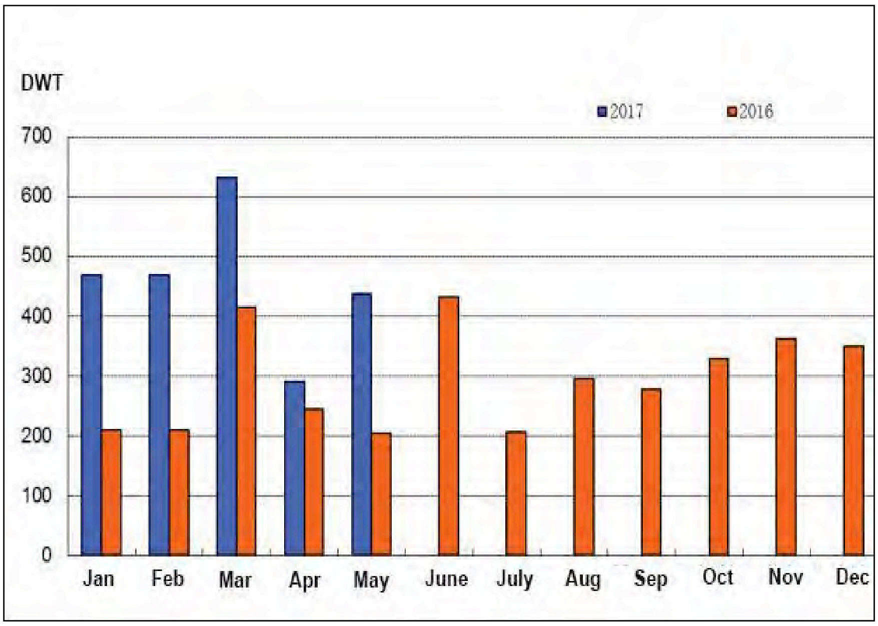


Figure 4: China completed tonnage Jan-May 2017

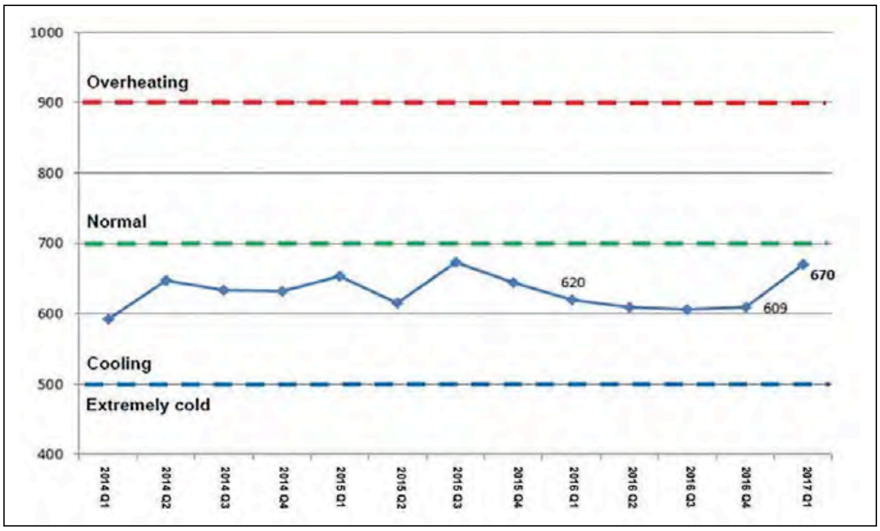


Figure 5: Quarterly CCI index in the last four years

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

Nominations are now invited for the 2017 Maritime Innovation Award. Individuals may not nominate themselves, although employees may nominate their company or organisation.

QinetiQ

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

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Nominations should arrive at RINA Headquarters by 31st December 2017.

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

A 'tool chain' for hydrodynamic analysis workflow

Hydrodynamic analysis is an evolutionary process that requires inter-related tools to strike the ideal balance between facility and precision, explains HydroComp's Don McPherson

Ship design is largely an 'evolutionary' workflow process, with design updates reflecting knowledge gained during loops around the design spiral. Each discipline (major dimensions, hull form, weights, powering and arrangement, to name just a few) will influence the others. In early stage design, knowledge is formational and about big decisions. Knowledge becomes more specific as the design matures and is constrained by the earlier design decisions.

Hydrodynamic analysis – whether that is for hull form, propulsor, or the integration of the two – follows these same evolutionary design stages. Workflow effectiveness benefits from tools that are appropriately matched to the task at hand. This article describes the rationale and organisation of a 'tool chain' for hydrodynamic analysis, from parametric studies through full CFD. Each stage sets the table for the next, with increasing precision and benchmarking for confident outcomes. This article will touch only on hull form resistance prediction, but the concepts and conclusions are equally valid for propulsor design.

An appreciation of order

To many, 'order' is the neatness of things (my mother would fit into this category). To scientists and engineers, order is a characterisation of complexity. Equation forms can help explain this. A line is of a lower order: Y = AX+B. With every additional exponent component in a polynomial, the order is raised: Y = AX3+BX2+CX+D. Each equation form is a model describing the output for a given input. Most would say that the higher order model better captures the outcome – but this is only true when the data is sufficiently refined. If you do not know the principal input data with certainty, a higher order model provides no more knowledge or usefulness than a simpler model.

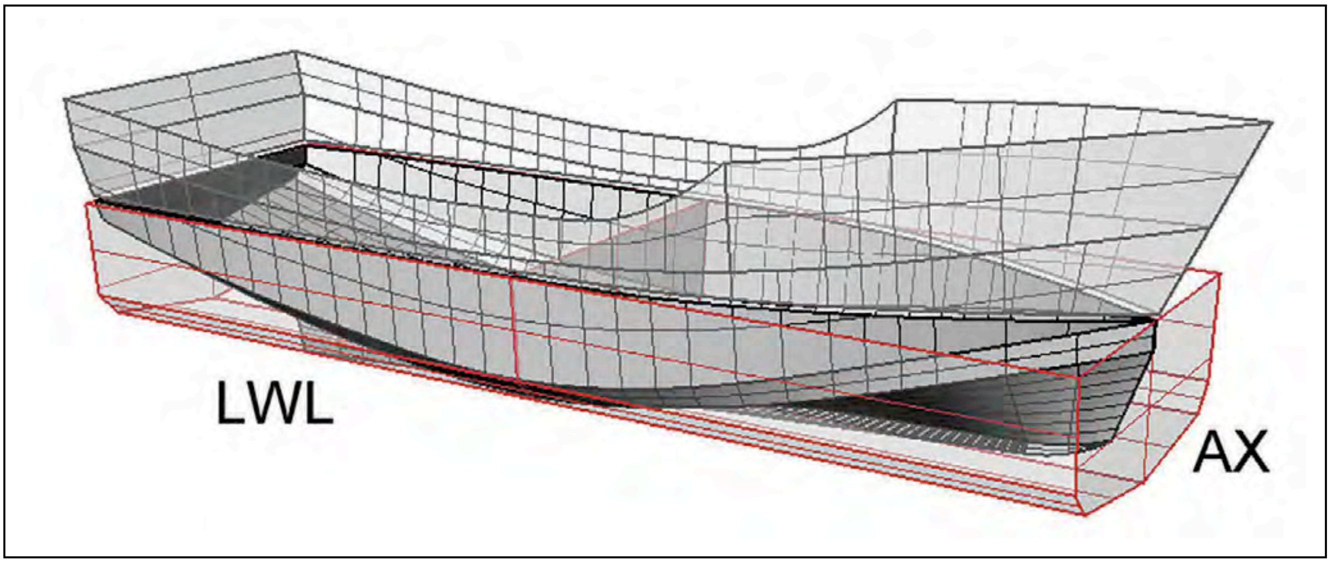
Computational models are numerical predictors of an attribute for the given data, and they are the tools of marine design and optimisation. In the context of hydrodynamic analysis, we have a wide variety of tools to manage our models for prediction of resistance and powering, from quick and simple charts that use just a few parameters, to full RANSE (Reynolds-averaged Navier-Stokes equations) CFD codes that require a complete description of the surfaces that are wetted. So which tool should we use?

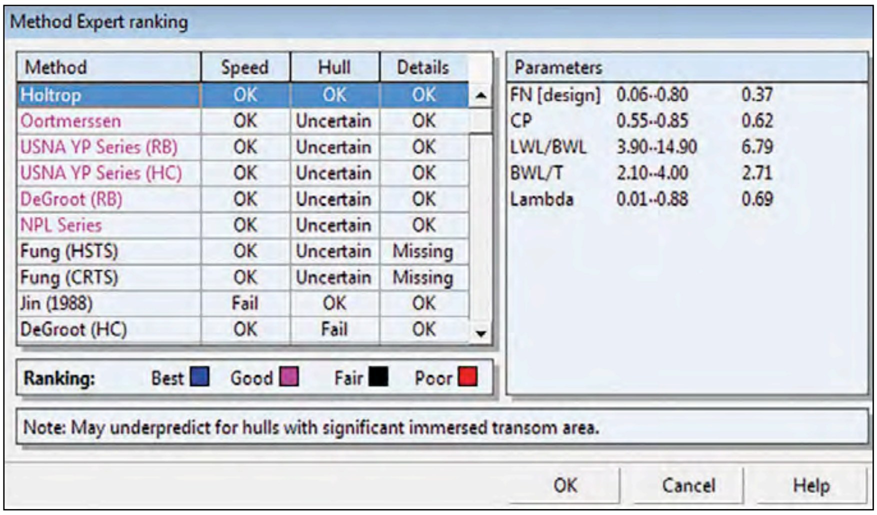
Design is an evolutionary process from lower to higher precision. All naval architects will be familiar with the design spiral, and this offers some insight into the value of having a connected hydrodynamic analysis tool chain from lower to higher order that gives the best 'value' for the 'cost'. In short, we need inter-related tools that hit the 'sweet spot' between facility and precision.

Data and prediction models

When we talk about models we must consider both sides of the coin: data and prediction. Hull form data models for hydrodynamic analysis represent the 'hole in the water'. Prediction models interrogate

Figure 1: Data models of hull form shape




Method Expert ranking

Method	Speed	Hull	Details
Holtrop	OK	OK	OK
Oortmerssen	OK	Uncertain	OK
USNA YP Series (RB)	OK	Uncertain	OK
USNA YP Series (HC)	OK	Uncertain	OK
DeGroot (RB)	OK	Uncertain	OK
NPL Series	OK	Uncertain	OK
Fung (HSTS)	OK	Uncertain	Missing
Fung (CRTS)	OK	Uncertain	Missing
Jin (1988)	Fail	OK	OK
DeGroot (HC)	OK	Fail	OK

Parameters		
FN [design]	0.06-0.80	0.37
CP	0.55-0.85	0.62
LWL/BWL	3.90-14.90	6.79
BWL/T	2.10-4.00	2.71
Lambda	0.01-0.88	0.69

Ranking: Best Good Fair Poor

Note: May underpredict for hulls with significant immersed transom area.

OK Cancel Help

Figure 2: HydroComp NavCad's 'Method Expert'

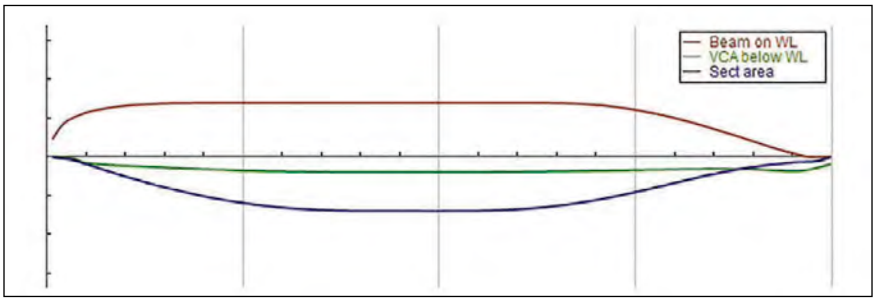


Figure 3: Longitudinal distribution of volume and waterplane characteristics (Duisburg Test Case)

the data and forecast an outcome. Hull form data, such as would be needed for resistance prediction, can be described in a variety of ways. The order of the data can be described in dimensional terms: [1D], [2D], or [3D]. Figure 1 illustrates the order of hull form data:

- Immersed parameter [1D]. These are significant parameters made up of one-dimensional values, such as length/beam ratio (the aspect ratio of the waterplane bounding box) or prismatic coefficient (the ratio of the immersed volume to the red extruded prism of maximum sectional area).
- Immersed volume [2D]. This is typically the longitudinal distribution of shape, such as waterplane cuts, sectional area curve, or the waterplane distribution.
- Immersed surface [3D]. The full 3D envelope is captured via the wetted surface itself.

Prediction models

This is where the strengths and weaknesses of the various hydrodynamic analysis software tools are exposed. They all generally employ one or more of the data models described above, but their capacity to predict performance can be quite different. We will consider a 'tool chain' that connects the workflow from [1D] through [3D] using HydroComp NavCad to illustrate the [1D] and [2D] links in the chain.

Parameter-based empirical prediction [1D]

These methods are largely derived from a statistical regression of historical data. In other words, they use what has already gone before to predict what may come ahead. One might therefore think that they are not very good at projecting or extrapolating beyond their own scope, but this is not always the case. If the method uses a framework that gives a qualitative structure – such as a curve shape that reflects the physics of ship resistance – then methods can extrapolate somewhat beyond their data limits.

Perhaps the most well-known parametric ship resistance method is the Holtrop method. This has wide application for non-planing monohull forms, but it still has its limitations. A comprehensive library of methods, is necessary to ensure that you have a method which satisfies the scope of the parameters and speed range. The Method Expert utility on HydroComp NavCad provides ranking and guidance to the user on the proper selection of a method for a [1D] parametric analysis.

Parametric-empirical methods can also be enhanced using a correlation technique that 'aligns' a prediction to a specific ship. Since many designs are derivative of earlier work, it is immensely valuable to be able to leverage the knowledge invested in model testing and/or sea trials to achieve the highest fidelity prediction for the new design. The 'Aligned Prediction' utility in NavCad provides such a capability.

At the conclusion of these parametric-friendly loops through the design spiral, the naval architect will have answers to those first-order questions of a ship's size, general shape, and powering requirements. They in turn provide the stepping-off point for the next refinement of the design.

Volume-based semi-empirical prediction (2D)

The shape descriptors employed in the parameter-based empirical calculations can now be extended to include a greater refinement of the longitudinal distribution of shape. For example, Figure 3 shows the longitudinal distribution of sectional area, waterplane (beam), and centre of immersed sectional area for a post-Panamax container ship with a bulbous bow. (This is the 'Duisburg Test Case', which is used as a validation benchmark for computational prediction models.)

This hull can be described parametrically as: 7.0 L/B, 3.5 B/T, 6.4 CVOL (fineness), 0.67 CP, 1% aft LCB. Of course, there are an unlimited number of shapes that can fit into that description. The longitudinal distribution gives us a more complete picture of the immersed volume.

This data distribution is used for resistance prediction by the Analytical Distributed Volume Method (ADVM) in the Premium Edition of HydroComp NavCad. It is a [2D] analytical wave-making code that also predicts the viscous properties at scale. It is suitable

Figure 4: Irregular waterline offsets through a propeller pocket

for monohulls and catamarans, and its prediction of resistance is independent of any statistical underpinning, making it useful as a prediction option for a very broad range of vessel types. The 'semi-empirical' aspect of the method is that certain diverging and transverse wave energy characteristics are constrained based on studies of many different hull types.

The foundation of the NavCad ADVM is an analytical wave-making prediction method similar to slender – and thin – ship codes, such as Michell Integral methods. It differs from these codes, however, in two key ways. First, the ADVM is not limited to thin or slender ships, and allows for successful prediction for wide (high B/T) ships such as the Duisburg Test Case illustrated in Figure 3. That being said, it does tend to somewhat over-predict wave-making for hulls with substantial buttock flow, such as barges and very shallow sailboats.

Second, and more importantly, the method does not use a waterplane cut technique (as is the case for a Michell-based method). Such methods are ill-behaved when they encounter irregular changes in waterplane geometry, such as through tunnel thrusters or propeller pockets. Figure 4 shows how a waterplane cut through a propeller pocket produces a discontinuous flow line. A simplification of the geometry would be required to achieve an outcome with a waterplane cut method. Of course, the local effect of such details is above the order of the [2D] design loop, and will be exposed in the higher-order [3D] CFD link in the tool chain. Instead of waterplane cuts, the NavCad ADVM employs sectional area curve and waterplane distributions which allow for a more well-behaved analysis with no loss of fidelity for the [2D] design and analysis objectives.

The wave energy component of ship resistance can also be communicated via its influence on wave pattern elevations. Figure 5 an example of a wave pattern calculated by this method.

The computational cost of a complete resistance curve and wave pattern plot is just a few minutes on a typical business-grade computer. This [2D] link in the tool chain is a very time and cost-effective option – especially when proceeding to the use of full CFD [3D].

Preparation for (3D) CFD analysis

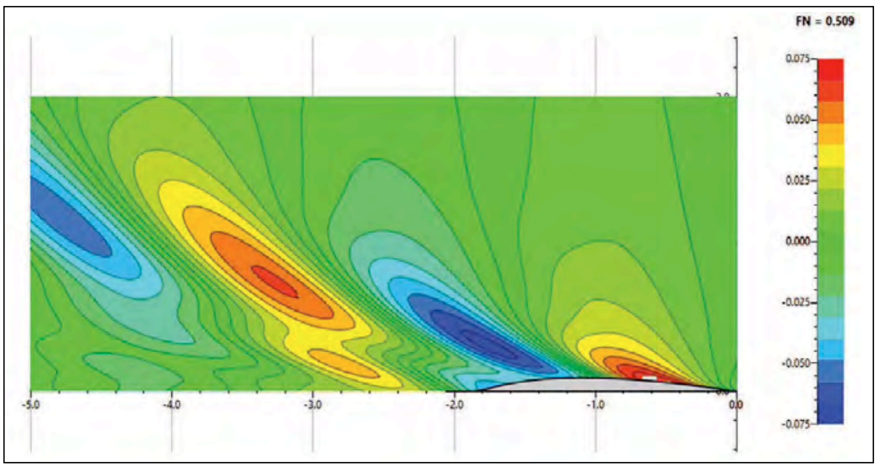
One key to successful [3D] CFD analysis is to first complete the [1D] and [2D] studies for the project at hand. Why? Since [3D] analysis is of the highest order, why should we not go directly to CFD?

The reasons for first conducting the [1D] and [2D] steps in the workflow will depend on the purpose of the [3D] computation. Mature and validated CFD is a complex model for predicting characteristics of fluid flow that allows observation of flow (unlike [1D] and [2D] analyses for the most part), works in a ship's native scale (without extrapolation from model scale), and can be used for design optimisation of local shape (such as the propeller pocket described above).

Some compelling reasons for using lower order analyses prior to [3D] CFD are:

- **For better analysis**. Analysis is all about accurately predicting attributes for prescribed data. It is the user's responsibility to make sure that both the data and prediction models are properly established. However, confidence in outcomes requires a benchmark. The lower order analyses provide these benchmarks, along with increased confidence, improved efficiency, and decreased risk.
- **For design**. Design is the application of analysis to investigate the influence of changes in data on outcome. It is typically an iterative process of 'test-and-move'. Test one condition, gain knowledge, compare to other condition, and move to a new and better condition. Repeat until the study converges to an acceptable definition of what is 'sufficient' or 'optimum'.

Figure 5: Wave pattern elevation calculation (Wigley hull)



Lower order analysis can very quickly and inexpensively conduct design studies suitable to pare down the set of 'all-possible-designs' to a manageable few that will meet the objectives and justify higher order study.

Rapid design space optimisation

The advent of more affordable and accessible CFD offers exciting possibilities for ship design. To insure that overall [3D] computational efficiency and cost-effectiveness is as high as possible, it is necessary to first make use of [1D] and [2D] rapid design space optimisation. With the introduction of the Premium edition, NavCad is able to provide integrated support for design optimisation, and naval architects can make CFD studies more effective by using NavCad Premium to 'set the table' for it.

A preparatory design space study establishes a starting geometry for CFD that is substantially closer to the final outcome, which greatly increases the success of analysed designs and the value of CFD. In addition to quickly narrowing the design space, NavCad Premium can also be used to assign confidence and validate the CFD model. Its predictions are quantitatively very reliable and robust, allowing follow-on CFD prediction values such as resistance or propulsor thrust, to be judged against those generated by NavCad Premium during its design space investigation.

What order of tool is needed?

We have described a tool chain for hydrodynamic analysis workflow by naval architects and designers. It is important, however, to remember that not all three links are necessarily needed for each project or task. It is fair to say that [3D] needs the preparatory steps of [1D] and [2D], and that [2D] builds upon [1D] analysis. That being said, when is a lower-order calculation sufficient? When is value gained by going to a higher order? *NA*

Tasks appropriate for [1D] analysis

- **Prediction of speed and required engine** power. Parametric methods can typically offer reliable prediction of speed and power for most ships and boats. However, selection of the right empirical-based method is critical, as is proper modeling of propulsors. NavCad's Method Expert, for example, offers this important user guidance. This is further enhanced with alignment to model tests or sea trials of similar vessels.
- **Selection of propeller parameters**. Propeller sizing (also called engine-propeller matching) can use [1D] methods to select the critical propeller and driveline design characteristics – propeller diameter and blade area, blade count, and even reduction gear ratio. Even if the design of the final propeller is to be off-loaded to a supplier, it is the responsibility of the designer to select the proper gear ratio (for shaft RPM) and principal parameters as they relate to the hull-propeller-engine system.
- **Initial design guidance**. The ship design process is not limited to hydrodynamic analysis. Designers are responsible for many other objectives – capacities, stability, structure, and more. At early design stages, naval architects do not need 'optimum' hull characteristics; rather they need guidance on general design 'trends' to reduce resistance and power. Parametric [1D] calculations are perfect to advise designers on how principal characteristics – maximum section area, LCB, transom immersion, bulb area – will influence resistance.
- **Benchmarking for [2D] analysis**. It is always beneficial to run a lower order calculation as a benchmark for the next higher order calculation. The [1D] parametric-empirical predictions can serve as checks of [2D] outcomes to make sure that the [2D] data model is correct.
- **When to proceed to higher-order analysis**. The parametric-empirical [1D] calculations as found in HydroComp NavCad will be sufficient if your objective is the quantitative prediction of speed and power for the purposes of determining maximum ship speed, selecting propulsion components, or investigating operational fuel consumption, for example. It is also suitable for forensic studies of existing performance. Running higher order calculations is justified if a qualitative optimisation of the immersed volume is needed, if the vessel does not well match the data set of a parametric method in the library, or for investigations of local characteristics of flow.

Tasks appropriate for [2D] analysis

- **Prediction of ship resistance**. The ADVM computation in NavCad Premium edition is not built from a regression data set, so its resistance predictions are independent of any particular hull type. This makes it an ideal companion to [1D] calculations as an additional confidence check. Like the [1D] calculation, these can also be enhanced with alignment to existing model tests.
- **Investigation of the influence of distributed shape changes on resistance.** When the principal parameters of a design (L/B, B/T) have been established, a [2D] computation can be used to investigate resistance based on the distribution of the immersed volume. This capability can be used to optimise and design hydrodynamically-significant features such as 'shoulders' in the sectional area curve, immersed transom area, length of entrance or run, or characteristics of bulbous bow geometry, for example.
- **Narrow the design space for [3D] CFD**. While computers are increasing in power and [3D] codes are becoming more efficient, the [3D] CFD computational requirements in time, skill, and resources are still considerable. Anything that reduces the number of iterations to find a [3D] solution makes the analysis more efficient and the entire project more profitable. The [2D] ADVM calculation – particularly if driven as a simulation solver by an optimising code – will 'set the table' for CFD by narrowing the design space for investigation.
- **Benchmarking for [3D] analysis**. As was the case for [1D] benchmarking of [2D] calculations, it is absolutely critical for the success of [3D] resistance predictions to have the knowledge derived from the [2D] link in the tool chain. Differences in outcome can point to potential errors in the [3D] data

model (such as incorrect gridding) or in CFD settings (turbulence models or convergence). While many CFD codes have a proven track record, user mistakes happen. Without the appropriate benchmarks from the lower order [2D] distributed volume calculation, it is often difficult to have sufficient confidence in the results of the [3D] CFD calculations.

- **When to proceed to higher-order analysis**. The distributed-volume [2D] calculations from the Premium edition of NavCad serve as an additional resistance prediction method that allows for a better understanding of the influence of volume changes. It can be used for design optimisation of shape characteristics, or on a broader level for narrowing the design space and making [3D] CFD studies more cost-effective and time-efficient with better outcomes. Full CFD studies are called for if localized optimisation is needed, if flow is to be observed, or as a final validation stage of the design spiral.

Summary

The evolutionary nature of ship design calls for a multi-order 'tool chain' for hydrodynamic analysis.

Workflow from [1D] parametric analysis through [3D] CFD requires computational models and tools that are appropriately matched to the task. An interactive suite of tools that hits the 'sweet spot' between facility and precision is critical for successful and cost-effective hydrodynamic outcomes. Fortunately, such tools are easily accessible and appropriate for any naval architectural office.

About the author

Donald MacPherson is an internationally-recognised specialist in applied hydrodynamics with particular emphasis on the design of propulsors. In addition to being the co-founder VP technical director of HydroComp, he is also an instructor of naval architecture at the University of New Hampshire.

Are rim-driven propulsors the future?

Rim-driven propulsors could come to play an important role in the propulsion of future electric ships. Steven Fletcher and Robert Hayes, engineers at Frazer-Nash Consultancy, present the technology's pros and cons and discuss the form future adoption may take for large commercial ships

The shipping industry has experienced a significant technology shift in recent years with increasing use of electrical propulsion systems. Electrical propulsion, supported by a substantial change in the ship electrical system, has allowed individual ship operators to experience benefits such as reduced maintenance and reduced fuel consumption, something that is helping to meet emission reduction targets.

As part of this response, it has been noted that advanced system design and technology implementation can play a key role in managing these emissions, with reductions in the order of 75% achievable according to the European Commission. This presents an opportunity for the further exploitation of low-carbon electrical propulsion designs and technologies, such as the rim-driven propulsors (RDPs).

RDPs are a novel and emerging electrical propulsion system that integrate an electric motor within a ducted propeller, resulting in a compact, electrically-driven propulsion package. RDPs have huge potential benefits for a range of applications because they remove the need for conventional mechanical drivetrains and open up a wide range of alternative platform arrangements. In our role as a systems engineering consultancy, Frazer-Nash has been involved in a number of studies seeking to assess the viability and benefits of RDPs for different application areas. Key areas of interest include the impact of such systems on ship architecture and electrical integration challenges, as will be discussed.

The following sections discuss why electrical propulsion can be advantageous and the types of power levels required to help illustrate what RDP systems must be capable of, before offering further detail on RDP systems and discussion of the challenges associated with their future application on large commercial ships.

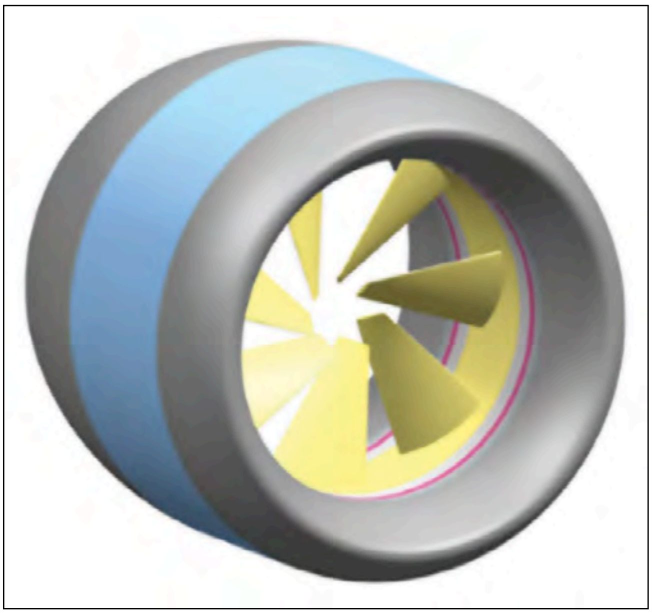


Figure 1: Hubless Rim Drive Design

Electrical propulsion

Electrical propulsion, where electrical motors are used to provide mechanical power to a propulsor, is increasingly utilised on a range of ship types and sizes. Examples of these include:

- Naval vessels (Type 45, Type 26, Queen Elizabeth Carrier, Zumwalt);
- LNG supply vessels;
- Cruiseships;
- Offshore supply vessels;
- Ferries.

There are three general ship configurations within which electrical propulsion may play a role. This can be in a parallel hybrid, series hybrid or fully-electric propulsion system. Using a parallel hybrid configuration, both an electric propulsor and an engine can provide propulsive power by connecting to the same shaft. This hybrid propulsion arrangement can provide operational efficiency benefits while retaining elements of traditional propulsion system operation. This configuration is not applicable to an RDP system, given the need for a mechanical shaft.

Fully electric systems can use energy storage (or potentially more novel electrical power generation technologies) to provide power to the propulsor. These are limited to short duration, lower power applications, such as ferries, given the limitations of available power sources (e.g. battery storage).

The majority of platforms described as having electrical propulsion feature a series hybrid configuration, which is where an engine (usually a gas turbine and/or diesel generator for ship applications) is used to generate electrical power. Power is then distributed and used to supply both ship service loads and the propulsion system. These ships therefore contain complex and highly integrated electrical systems. This can bring its own challenges (e.g. the well publicised? issues experienced on the Type 45) as well as many opportunities for optimisation.

Why is electrical propulsion advantageous?

Electrical propulsion (in the series hybrid system configuration) has a range of potential advantages which has supported the increased uptake in its implementation.

In terms of power generation, by breaking the mechanical connection between the prime mover (e.g. a diesel engine) and the propulsor, it provides the ability to distribute prime movers, and associated electrical generators, around the ship. Removing prime movers from the base of the ship can reduce noise and vibration and the location of propulsors is also made more flexible.

Electrical propulsion provides the ability to use smaller distributed prime movers, enabling optimal use across the operating profile by matching the number of operating prime movers with demand. This configuration can also support greater system redundancy and availability.

These and other benefits combine to offer a more flexible ship design and propulsion system which reduces emissions, fuel consumption, mass, volume, noise and vibration levels and maintenance costs.

As a future potential benefit, the flexibility offered by electrical propulsion may facilitate the integration of contra-rotating propellers, which have been demonstrated to provide improvements in propulsion efficiency.

How much power is required?

The level of propulsive power required on a given platform will have a significant impact on the suitability and availability of rim-drive technology. Propulsion power requirements vary widely, based on ship size and top speed requirements, and clearly ship architecture will determine the power rating of individual propulsive units. To provide some examples:

- Offshore vessel propulsive power is in the order of 4MW, with main propulsors around 2MW (there is a larger variability given the number of platform configurations) [1];
- Cruiseships may use propulsors rated between 7.5MW and 15MW;
- The Yamal LNG tanker uses three 15MW propulsors;
- The Type 45 ship and the QEC both use 20MW propulsion units (two on the Type 45 and four on the QEC);
- The Zumwalt ship is designed with 70MW of propulsive power, provided by two 34.6MW motors.

These existing applications help to judge the potential scale of RDPs if they are to replace current electrical propulsion systems.

Rim-driven propulsion

While electrical powered propulsion is now well established, opportunities exist to further improve these platforms in areas such as controllability, efficiency and reliability. RDPs are one such emerging technology under investigation for this purpose.

An RDP is a propeller type which does not need a hub for transmission of the driving torque. In these thrusters, the stator of the electrical motor is housed within the thruster duct, and the machine rotor forms a ring around the tips of the propeller, onto which the propulsor blades are rigidly attached. An example design is illustrated in Figure 1 [2].

A rim-driven motor can technically be driven by any electrical machine type (e.g. DC or induction motors), but there is a general preference for permanent magnet machine types due to the greater power density and efficiency that they offer. This is reflected in the commercial offering available. In this configuration, a ring of permanent magnets are mounted on a rotating rim as Figure 2 illustrates [3].

There are a number of potential advantages in the use of RDP systems over more conventional electrical propulsion. At the individual propulsor level, RDP systems can reduce acoustic noise signatures due to a reduced propeller tip speed (note however that there are a range of sources of noise and calculation of this can be complex [3]). RDP electrical machines are generally high torque and low rpm to deliver this performance. Weight can be removed from the propeller due to the removal of the shaft, enabling more rapid control of the rotational speed. However, the significance of this depends on the size of the propulsion (i.e. this will have proportionately more impact in smaller systems). Certain designs can be cooled by the surrounding water and so no separate cooling system is required for the RDP [4]. However, this may not be the case for high rated RDP units, due to high current carrying requirements, and hence increased heating, of machine windings.

The full benefits of RDP technology are seen when considering the potential impact on whole ship architecture. The removal of the shaft allows for units to be positioned with more freedom, which opens up the opportunity for novel configurations to provide enhanced platform capability (e.g. multiple unit primary propulsion, secondary propulsion, dynamic positioning or hover control).

One key area of interest is the potential impact of RDPs on hydrodynamic

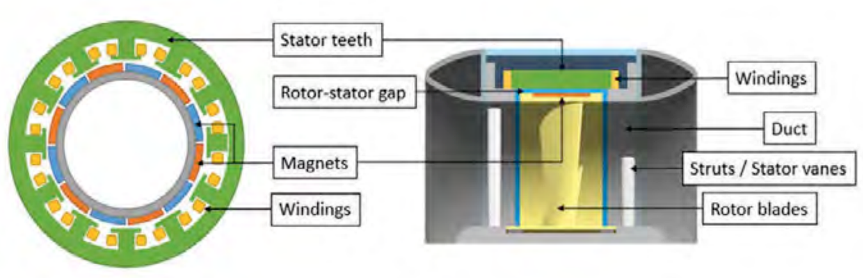


Figure 2: Meridional and Axial Cross Sections through a RDP

efficiency. Initial published research, based on a scaled cruiseship model, estimated that an efficiency improvement in the order of 7% was achievable [4]. This level of benefit is also reflected in the information published by Rolls-Royce on its rim-driven thruster technology. This is significant as it not only reduces the total energy consumed from ship propulsion, but also reduces the total installed generation power on the ship, associated infrastructure and fuel usage, saving cost and space. Such an improvement would facilitate a reduction in ship size or an increase in payload. Alternatively, higher speed operation could be achieved for the same installed power.

To explain the potential hydrodynamic benefits in more detail, it is due to the interaction of the hull and the development of the boundary layer that the flow into and around the propeller is non-uniform. Aft-end design plays a significant factor in shaping this flow, and overall propulsive efficiency is a combination of an aft-end that trades off hull resistance for improved propeller inflow.

On a conventional single or twin screw ship the aft-end design is limited by shafting line, propeller clearances and rudder locations. With an RDP the propulsion units can be placed in a location that stops the flow from being impeded (e.g. under the hull). This decreases variations in blade loading and promotes cleaner flow which would be expected to increase the propeller efficiency. This can be matched with either a pram-type stern or bulbous stern, both of which promote buttock flow and decrease overall hull resistance. There is a potential risk that the flow may stall slightly due to the hull not accelerating flow into the propeller. However, the ducting of the RDP would seek to offset this. The duct would increase propulsive efficiency for a given propeller size for high thrust, slow speed applications (e.g. oil tankers), but higher speed vessels (e.g. cargo ships or naval vessels) may be negatively affected by the duct.

There are a few usability issues on vessels with RDP. First, most designs are confined by draught and therefore the design would need to place the RDPs in a stern tunnel configuration, offsetting many of the gains with regards to clean flow. Second, there still needs to be sufficient flow over a control surface to enable manoeuvrability even at slower speeds. The RDP could azimuth, but previous experience with podded propulsion has shown this to be unreliable (with pods being lost in transit). Finally, any type of unit attached to the vessel with a large projected area will have a significant drag component both from the struts and from the unit itself.

Which applications currently employ RDPs?

RDPs currently exist as COTS technology and are used as bow/stern thrusters and as propulsion units in azimuth pod and retractable configurations. RDP units are in-service across a range of commercial applications, including yachts, ferries, tug boats, offshore support vessels, research vessels and cruise liners. In total, it is estimated that there are between 100–200 rim drives in service within commercial applications. The majority of these units are below 0.5MW rated power.

To date, propulsion applications have been a smaller part of the market compared to tunnel thrusters. Frazer-Nash has recently undertaken an investigation into propulsion applications, which involved the testing of two 500kW propulsion units on a research vessel. This trial demonstrated improvements in energy consumption and vibration transmission, compared to conventional shaft-driven propellers and suggests that the technology offers an attractive solution for future electric ships.

A number of larger scale RDPs are also coming to market and will play a role in the propulsion of future platforms. Examples of these include RDPs of up to 1MW from Schottel and Brunvoll and between 1MW and 3MW from Rolls-Royce and Voith.

What are the challenges?

A key constraint in the wider utilisation of RDP systems is the availability of high power units. Clearly there is a disparity between the RDP ratings currently available compared to the size of the motors used in larger commercial and naval applications. While there are no fundamental issues that would prevent RDP systems being upgraded, Frazer-Nash research has found that significant design changes are likely to be required for the multi-megawatt units needed for application of RDPs on large commercial vessels. Issues may include the design of bearings and cooling. There will also be significant costs associated with the design, manufacture and testing of these higher power devices. Interestingly, research has even been conducted on highly novel superconducting electrical machine types at this power level [5].

The design of a power electronic drive to supply the RDP may also be an issue. The electrical machines in RDP are typically designed with a high number of pole pairs (these being pairs of machine windings and magnets) for optimal size and efficiency [6]. This means that despite the low RDP rotor speed, the electrical frequency from the drive is much higher than typical industrial motors of similar power (which are designed around 60Hz operation compared with a possible range of 100-300Hz for RDPs). Ultimately, this requires the drive to be switched faster, increasing switching losses. Managing the associated thermal issues can be more challenging as power levels scale up.

There are also several challenges of scaling up this technology to larger ships from a hydrodynamic and structural design point of view. A single large RDP will experience large drag and thrust components and subsequently there will be high cyclic loading on the structure. Podded propulsion units have had issues with being lost in heavy seas and it is envisioned that RDPs could be even more susceptible to this occurring. To minimise the risk of this occurring the RDPs would either need to be anchored by multiple attachment points or a large single strut: in either case the likelihood is that azimuthing capabilities would be impacted. In addition, single propulsion units would be unsuitable due to risk of loss.

Given that single commercially-available units are unlikely to be sufficiently rated to provide all the propulsion power needed for the vessel, the RDPs would need to be stacked. However, this could be configured advantageously by stacking in a contra-rotating fashion, which is easier to achieve for RDP given the flexibility in location). While increasing the number of RDPs required, this could potentially provide increased recovery of rotative losses, leading to higher efficiency.

The development of RDP for higher power applications is achievable, but significant development and demonstration will be required in order to scale up this technology. On this basis, it may be a number of years before RDPs fully challenge conventional electrical technologies for large ship propulsion. *NA*

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Advancing safety in the containership sector

Bigger boxships demand a firefighting infrastructure with enhanced capacity, explains Matthew Tremblay, ABS vice president for containerships.

As recent incidents have demonstrated, the risks from a containership fire increase as the number of containers onboard rises. As container stacks have increased in height and number, the opportunity for a fire to grow in size and scale has grown with them.

We know from our discussions with containership operators that this is a critical risk to their operations which they wanted to address.

Key for the owners and operators is the ability to protect life and cargo onboard. ABS is constantly looking at new approaches to expand safety in the industries that we serve and consistent with the ABS mission to protect life, property and the marine environment, we decided to move forward with the development of a new standard for fire safety.

The result was an update to our guidance for existing containership tonnage, the *ABS Guide for Fire-Fighting Systems for On-Deck Cargo Areas of Container Carriers* (FOC Guide). By applying the guide, containership owners can apply the same degree of assessment and review to their active fleets that they do for new construction and demonstrate a commitment to safety and fire protection that supports more secure operations.

The primary technical challenge of firefighting is not necessarily structural, but mechanical. As stack heights grow, the systems that supply the fire water to the container decks must have the ability to move a greater volume of water at higher pressures over longer distances. Therefore, building a robust water distribution system with suitable redundancy and capacity is the primary challenge.

The new code goes above and beyond the IMO requirements (SOLAS 365 (93)) in several ways. In particular, the FOC notation requires at least twice the amount of water capacity be available to the container deck.

Matthew Tremblay

It also requires that the piping be arranged in a redundant 'loop' type design with isolation valves that would allow the system to isolate damage and operate after a single break in the piping system.

FOC also requires approximately twice the number of fire water monitors (nozzles) than is required by IMO, dependent on vessel size. The FOC+ notation adds a requirement for the protection of the hatch covers that is not addressed by the IMO regulations.

FOC-R is a modified version of the FOC rules that were developed as a means of applying the lessons learned creating FOC to existing vessels. While FOC is intended to be applied to new construction, FOC-R applies the aspects of FOC that can be reasonably installed and retrofitted on an existing ship during a normal drydocking.

In researching the topic to create the new guidance, our main task was to evaluate the water supply capacity that would be required to shield the radiant heat from a container fire from igniting a new fire in an adjacent bay.

This was primarily accomplished through the use of 3D fire modelling software that can predict the transfer of heat from one location to another. Multiple fire scenarios were modelled to determine the minimum water capacity that would be needed to create a reasonable water spray barrier between container bays.

A containership fire is very difficult to extinguish. In most cases, a ship crew's best hope is to contain the fire and let it burn out. The physical activity required onboard to operate these firefighting systems is both dangerous and strenuous.

In considering the most important factors naval architects should be aware of from a design perspective when seeking to manage fire risk onboard container ships, the arrangement of the access ways and equipment should be optimized for the safe and efficient use of the crew.

Whether or not we have seen the pinnacle in terms of ever-bigger containerships has implications for fire safety and also other technical factors. As naval architects, we are technically capable of designing even larger vessels than the biggest ships being built today.

The biggest factor currently affecting the continued growth of container ships is the shore-based infrastructure required to support them. There are a limited number of ports that can currently handle a 20,000 TEU-plus ship. While slot costs may continue to decrease as vessels get larger, the overall functionality and flexibility of the vessel decreases as it can operate in fewer and fewer ports. Ultimately this is a commercial decision that the liner operators will make as trade conditions evolve and new technologies are incorporated into ship designs.

However, the most significant trends we observe in terms of containership design are around safety of the cargo. Container deck firefighting is one of the biggest areas of concern for ship owners today.

We have received significant feedback on the publication of our FOC and FOC-R notations from owners looking to implement the rules.

Container lashing analysis is also an important topic. As container stacks get taller, the effects of their movement at sea grow in significance. Traditional analysis methodologies for designing lashing systems are no longer able to accurately predict the dynamic loads applied to lashing equipment in taller stacks.

This led ABS to publish its new *Guide for Certification of Container Securing Systems* (The Lashing Guide) and new companion software, ABS C-LASH. Central to the Lashing Guide is a newly developed non-linear lashing analysis procedure that represents a significant improvement over traditional formulas for container securing.

ABS classes one fifth of the current containership orderbook

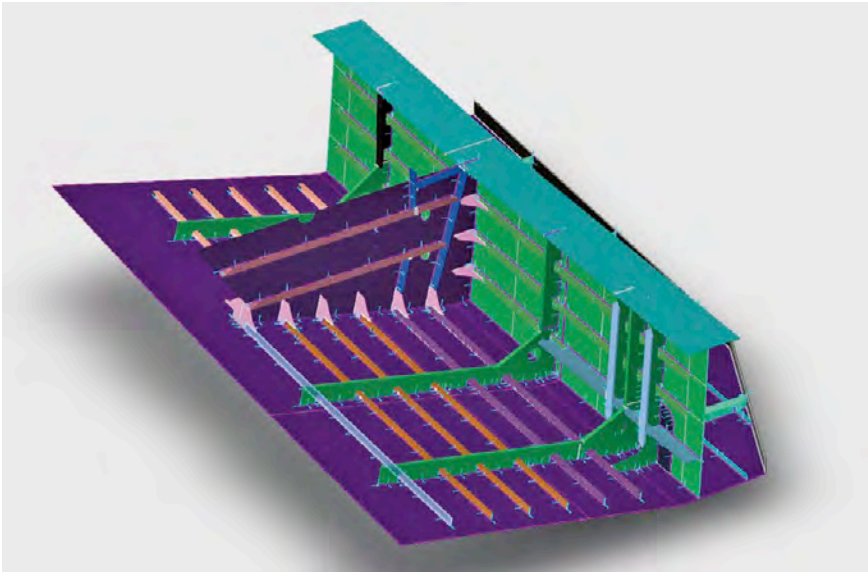
Coupled with new easy-to-use software that simplifies analysis of container lashing arrangements, the resources enable a more accurate representation of the loads in taller stacks, allowing operators and designers to develop safer, more efficient lashing system arrangements on board. *NA*

Robotised welding: a great leap forward?

Shipbuilding is leading the way with a pioneering integration of CAD and robotics developed in the US offers a fresh solution to a long-standing challenge

When writing about advancements in shipbuilding, typically the emphasis is on applying innovations in technology from other industries. With Computer Aided Robotics Welding (CAR-W), it is the shipbuilding industry itself that has developed a solution that is beyond anything done before.

Of course, robotic welding, in and of itself, is nothing new. It is used in car manufacturing and in high-volume shipyards producing a series of tankers which have many common assemblies in the mid-body. However, the vast majority of shipbuilding scenarios are not like that. It often shocks outside observers to learn that almost every single assembly on most ships is unique so until now, it has been impractical to use a welding robot because programming a robot for each scenario would outweigh any time saved.



Welds identified in ShipConstructor CAD software

That has now changed. On June 27 and June 29 2017, Bollinger Shipyards in Lockport, Louisiana, USA demonstrated to impressed onlookers from government and multiple industries, how a Wolf Robotics 9-axis robotics gantry could weld complex ship structures on Bollinger's production steel panel line. The demonstration was not just on flat panels. The robot handled vertical welds, curved structures and wrap conditions too.

This is new technology, pioneered under the umbrella of a National Shipbuilding Research Program (NSRP) project. The NSRP is an organisation funded by the US Navy and United States shipbuilders. The project successfully demonstrated a cost-effective approach which enables robots to produce complex, low-volume shipyard assemblies where automation was previously cost-prohibitive. CAR-W now makes it possible to generate accurate, collision-free robotic welding routines in minutes, regardless of part complexity.

ShipConstructor software

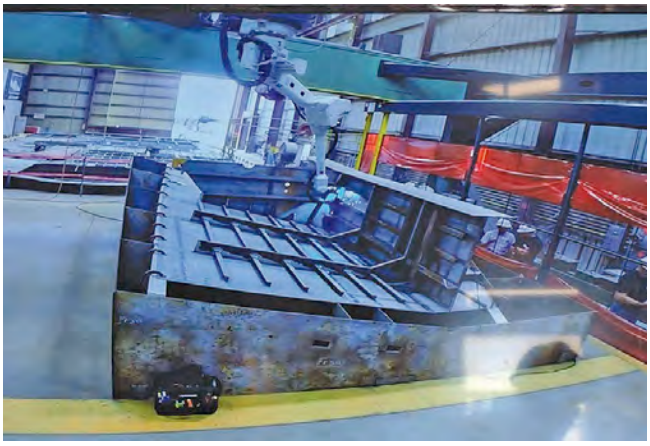
The key to making this project work is the tight integration between the welding robot and SSI's ShipConstructor CAD/CAM software via SSI's EnterprisePlatform. This connects robotic welding cells to a shipyard's digital thread. The CAR-W software tool links proprietary weld process parameters directly to weld callouts in the ship model, enabling automatic process selection for each weld seam. This allows shipyard personnel to quickly produce robot welding programs with low effort and minimal training.

To emphasise how significant this is, it should be noted that normally, it would take days to capture the welding information and program the robot for a single assembly. But with this project, the NSRP team developed a solution that transfers the welding information already contained in the ShipConstructor 3D product model to an automatic robot path planning tool. The welding information transferred contains all the relevant attribute information which the planning tool uses for all the complex 9-axis kinematic math. This streamlined process produces the results which can drive a robot collision-free with pinpoint accuracy. The new process significantly reduces the amount of time needed to prepare an assembly for robotic welding and therefore it will now be cost-effective for the majority of global shipyards.

Many companies and organisations worked together on this project. The NSRP CAR-W team included: Bollinger Shipyards; Ingalls Shipbuilding; Naval Surface Warfare Center–Carderock Division; Wolf Robotics, LLC; ShipConstructor Software USA Inc. (SSI); Edison Welding Institute; Purdue University; Colorado State University and Longview Advisors, LLC.

History of development

To accomplish this success, Wolf Robotics had to figure out solutions to many kinematics issues, while on the CAD software side, the demonstrated solution is also a result of years of SSI's incremental development related to welding. SSI's journey started back in 2007 with an NSRP project on weld management. That project was focused on automatic weld generation, identification, traceability and documentation. That project provided a lot of insight and captured industry expertise. After successful completion, SSI then invested over three years to create a software product called 'WeldManagement' which has now been used by SSI's clients for several years.



CAR-W demonstrated at Bollinger Shipyard

The next stage of SSI's journey was the creation of the 'EnterprisePlatform' which allows extraction of information contained within the ShipConstructor CAD/CAM software's Marine Information Model (MIM) in a context that can be consumed by other programmes and machines. The SSI EnterprisePlatform was a key reason why SSI was able to provide the deliverables Wolf needed in the short time span of the project

The Future

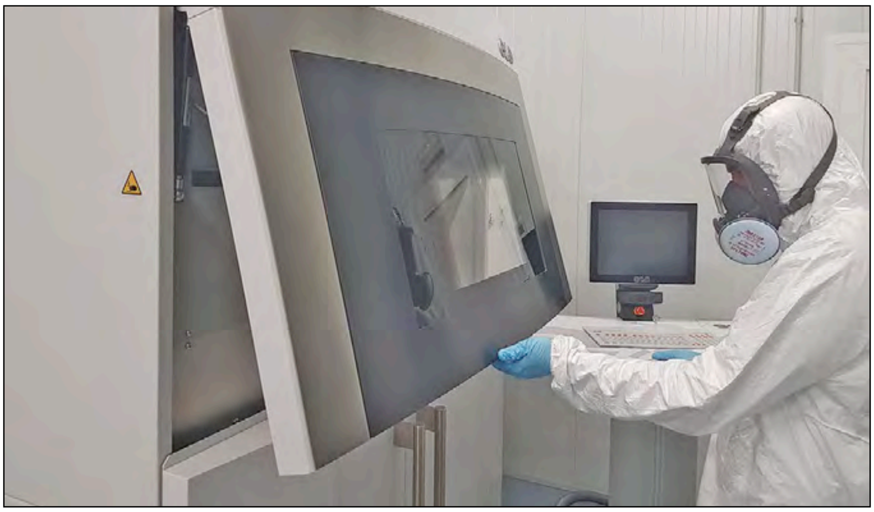
The demonstrations of this technology were so impressive that the NSRP has agreed to award another project which will expand the capability of what was achieved by adding several enhancements such as laser scanning to recognize clamps on the metal being welded. Meanwhile other industries have expressed interest in this innovative technology. When it comes to Computer Aided Robotics Welding, the shipbuilding industry is leading the way into the future. *NA*

Additive Manufacturing: the future is now for shipbuilding

First appearing in the mid 1980s and conceived as an ideal tool for designers and forward-thinking industrial engineers to create intricate structures and complex prototypes out of polymers, 3D printing and the creation of parts using layer-by-layer building fused together with laser heat has been around for quite some time

Taking its inspiration from structures found within nature, such as skeletons and coral reefs, for example, the 3D printing principle is based upon lattice structures that combine maximum loading capacity with minimum material and weight – a highly resource-efficient building process when you think about it.

Now, with almost 100 different polymers and the more recent integration of new 'serious' industrial raw materials;



Larger 3D printers are now capable of printing in areas as much as $1m^3$

sophisticated metals in powder form such as 316 Stainless, Titanium & Aluminium alloys, Iconel, high yield strength steel and even some traditional brass and copper metals, the 3D printing concept has made huge strides.

Industrial 3D printing (also referred to as Additive Manufacturing (AM)) is now taken very seriously as a realistic alternative to more traditional methods such as casting, machining and welding. AM has the potential to eliminate many conventionally made parts into a series of far fewer 3D parts, the largest machines available are now able to print in areas as large as $1m^3$ and high levels of accuracy from intricate shapes and complex geometries can now be achieved.

Yet while high-tech industries such as Formula 1 and the aeronautical industry, for example, AM even for highly critical parts connected to safety, it's been a much slower adoption process for traditional heavy industries, such as shipbuilding and ship repair.

Based in the traditional maritime and shipbuilding region of Pontevedra, Galicia, NW Spain, is the Vicalsa Group, whose engineering and heavy industry capability handles the maintenance, refit and conversion of a high number of significant commercial vessels over 100m.

Vicalsa, CEO, Anxo Mourelle, (also CEO of Vicalsa's superyacht facility, Atollvic Shipyard Group), has already invested in the 3D printing concept by creating the company Lupeon and foresees a time when Additive Manufacturing becomes a far more common process within shipbuilding:

"We are now printing these new materials in their purest form and with the appropriate manufacturing skills, quality is better than from a foundry. We are gradually seeing other shipyards and technical representatives becoming more & more aware of the huge potential of AM for special parts.

"The main advantage is connected to its root characteristics: adding the exact amount of material in successive micro layers (between 14 and 100 microns each) until the desired construction is complete.

"A number of other important benefits include better optimisation of weight of around 70% or more real time savings of metal parts leading to less mass inertia, less maintenance and less noise due to vibration.

"We can build with absolute design freedom. Moving industry from design-to-manufacturing to design-to-function is a game-changer and frees the user of problems and limitations connected to a more traditional approach of moulding/casting (rejections or air bubbles) or machining & welding (straight channels, limited complexity, material scrappage etc).

AM is still a maturing technology, 'printed' parts still need sanding and grinding, but it does make the manufacture of bespoke components easier

Mourelle says that this makes it possible to deliver bespoke components easily, because no complex moulding procedures are required. Moreover, the 'click & print' principle allows the facility to work around the clock and deliver those products within a matter of a few days or less, depending upon their size and complexity.

"We can also offer 'reverse engineering' whereby if we have an example of the old part that needs remanufacturing, we can build a new one by high precision 3D scanning of the old part to create the digital file we need. Customers are not committed to paying for a minimum number of parts either because the process allows from one to infinity parts without penalising the customer."

Like others who are gradually starting to offer Additive Manufacturing as a service in shipbuilding, Mourelle is not so naïve as to think it's the answer to all our prayers and says: "When the part is properly designed the price is comparable to a conventional process, but the performance and beauty often aren't. Let's be clear about this, Additive Manufacturing (industrial 3D printing) is not here to substitute traditional machining and moulding/casting methods, far from. Furthermore, virtually any part produced by AM still requires post processing by conventional technology such as sanding, grinding, shot peening, surface treatment or painting.

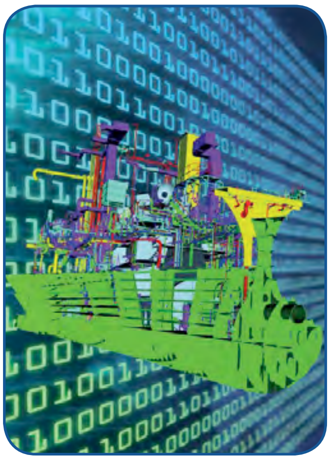
"But what AM does bring is a synergy of cooperation, let's say, between the old and the new. We can now use traditional machining to create solid parts of a medium to large size, then add a highly complex element to this through AM in form of 'hybrid' manufacturing that brings an advantage to the end-user. What we will soon be seeing in shipbuilding and repair are workshops where 3D printing shares the building process with traditional manufacture.

"After our own 45 years of marine tradition we have learnt the value of innovation and see this new emerging technology as the best way of solving many of our customer's problems and requirements."

While in the total scheme of things, Additive Manufacturing still represents only a very small percentage of the work they do on ships, recent examples of Vicalsa using this technology in the last few years have included the manufacture of a small number of intricate parts requiring finite engineering detail - parts that would have been hugely time-consuming and expensive if left to traditional methods.

Examples include various light supports and light mounts for the Suardiaz Line of RO-RO car carriers, including the *Suar Vigo* (149m, built 2003) and the *Bouzas* (142m, built 2002). Car deck special connector parts for the Balearia Line's *Regina Báltica* (145m length, 1,675 pax car ferry) and specific parts for control panels, doors and hatches on the *Pacific Star* (105m trans-oceanic tuna fishing vessel, built in 1990). *NA*

To find out more about Vicalsa's steadily growing use of Additive Manufacturing in shipbuilding visit www.lupeon.com or contact Anxo Mourelle, Director General / CEO, cell: +34 673 616 802 or office: +34 986 213 753, or by email: anxo.mourelle@vicalsa.com



Helping shipbuilders engage with their digital asset

AVEVA's Gabriel Powell, business development manager for shipbuilding and offshore, and Eric Rousseau, vice president - marine solutions, explain how life cycle information management improves the decision-making process

The shipbuilding and offshore industries are facing a surge of new technology with smart ships and 'thinking machines' capable of learning smart operations. Yet, when it comes to information – the very substance of that smart technology – we tend to think of it as a lifeless entity to be produced, manipulated and stored.

That may be partly because technology has traditionally focused on the processes around engineering information, rather than its essence. We have indeed replaced manual methods with automated and semi-automated processes. This has made it possible to produce, manipulate and store data more effectively. It has also increased our ability to control and understand ever larger and more complex engineering information assets. But how do you infuse that spark of life into engineering design processes to turn data points from passive outputs into active contributors?

Now in its 50th year as an engineering, design and information management software solutions provider, AVEVA has adopted a Digital Asset approach. The Digital Asset is neither a software application or solution, but rather the collection of engineering information that describes a physical asset and the framework that brings this engineering information together.

In other words, it is a digital representation of the given plant, building or vessel. During his keynote address at the 2017 NSRP (National Shipbuilding Research Program) All Panel Meeting, rear admiral Lorin Selby – chief engineer and deputy commander for ship design, integration and naval engineering for Naval Sea Systems Command (NAVSEA) - referred to this as 'the Digital Twin' and the two terms are usually regarded as synonymous.

The Digital Asset approach to engineering information management is new, in that it uses advanced technology which can function with data from any source. This is what we call data-agnostic. In fact, every physical asset already has at least some digital engineering information that describes it. The Digital Asset approach unlocks the potential value of this engineering information. It enables further engineering information to be continually added, managed and made use of.

The fundamental principle of the approach is that engineering information should not be considered as transient. Engineering information has an importance that may persist throughout the entire vessel life cycle, from the initial concept phase through shiprepair and modernisation. Engineering information forms the basis for every decision we make, so it should be maintained, kept 'alive' and relevant, with the same diligence as its physical equivalent. It should be made available quickly and easily to everyone who needs access to it, whenever and wherever they need it.

Removing barriers

To coincide with the Digital Asset approach, AVEVA has developed a new type of application, known as AVEVA Engage, that

AVEVA Engage combines visualisation of an entire model with data and engineering information to create the Digital Asset allows you to instantly realise a Digital Asset through a simple touch-driven interface. It is intended to support the widest possible range of activities where intuitive and immediate access to the Digital Asset is valuable. The application is Windows 8.1 and Windows 10 compatible for large touch screens. It combines Ultra High Definition (UHD) visualisation of an entire model with access to the data and engineering information that makes up the Digital Asset of a plant, building or vessel.

Being able to engage with the Digital Asset via a large touch-driven screen removes barriers to collaboration and decision making. It socialises the Digital Asset by combining engineering information and documents, and situating it within a visually-centric and navigable 3D model. By putting the Digital Asset right in the hands of those who need it, precisely when and where they need it, touch screen applications allow users to cope with the increasing pressures of lean design, capital stewardship and operational reliability.

It is widely accepted that, with better information and more intuitive applications, we can expand what is possible in engineering and design. The Digital Asset approach allied to touch-driven screen software will become an integral part of decision workflows across the end-to-end shipbuilding project and operations life cycle, which includes:

- Design decision support processes
- Design review process
- Constructability review process
- Commissioning planning
- Central control room work overviews
- Problem solving
- Work-planning processes
- Creation of preventative maintenance jobs
- Engineering information access during repair
- Modification project planning

Not so long ago, most large projects had a large-scale plastic model created to help give the engineers confidence that their designs would work. The model room was the ultimate in 3D accessibility as you could literally walk in with colleagues and have a discussion, while taking measurements.

The advent of Digital 3D has arguably reduced accessibility to 3D for decision making as you need a powerful work station, a copy of some software and a CAD monkey to run it. Touchscreen applications are designed to give that same level of accessibility to a 3D model as the plastic engineering models of yesteryear. You walk into the room, pick a model, and it appears in front of you in seconds in large scale. The application requires no training, making it comfortable for all types of project stakeholders to use.

Case Study: Lundin

Lundin Norway, a subsidiary of Lundin Petroleum, carries out oil & gas activities on the Norwegian shelf. The basis for Lundin's strategy for value-creation is their ability to utilise existing engineering information and to create new knowledge. Lundin is able to achieve this using the Digital Asset with AVEVA Engage for the *Edvard Grieg* platform, located around 111 miles west of Stavanger, Norway, in the North Sea.

When it comes to operations, maintenance and repair, according to operations manager, Geir Sjøsåsen, Lundin's philosophy is that "everything that can be done onshore *should* be done onshore. Our offshore personnel should only execute planned work. I believe the 3D model makes it easier to realise this. Mechanical, electrical, instrument and process personnel in operations are the primary users of the 3D model. All engineering information required to plan a repair job is presented in one screen: parts, equipment history, future jobs etc. There is no need to access multiple systems to find engineering information. It's all here, which is a big advantage."

While using the application, Lundin discovered they could easily find highly-detailed engineering information, all the way down to specific tag details. "We can, for example, from a 3D object, open the documents and view P&IDs," says Sjøsåsen. "We can see if we have associated data and whether we have done some work on it before. You don't have to leave the 3D model; you find all the data you need here. That's elegant. You don't have to access three or four systems to find the engineering information you need for the job."

Greater decision support

If you recall, we questioned how we could infuse the spark of life into the information generated by engineering & design applications, turning a passive output into an invaluable contributor to key decisions in life cycle management. The key is to ensure that engineering information of known maturity and reliability is made available to those who can benefit from it, when and where it is needed.

The traditional limitations of an application's scope to its own specific type of information need no longer exist. By providing direct access to the extended Digital Asset, engineering design companies are not only blurring the boundaries of the scope of design applications, but also substantially improving the efficiency and effectiveness of the decision-making processes in design through life cycle support.

This intuitive and easily-accessible context technology eradicates time-consuming and disruptive searching for engineering information, and removes many limitations on the ability to make prompt and well-informed decisions. Whether maintaining an oil & gas platform in the North Sea or your typical passenger ferry, the same challenge exists for users across the project and life cycle for almost all industries. This inclusion of context technology is just the first step towards adding greater decision support capabilities.

About the authors

Gabriel Powell is a sales and marketing executive based in Houston, TX. He joined AVEVA in 2013 and is currently a business development manager, responsible for the growth and development of the shipbuilding and offshore business in North America. He holds a BBA in Marketing from the Texas State University, San Marcos, and received an MBA in Sales Leadership and Global Management from the University of Houston.

Eric Rousseau is a naval architect graduate of the Quebec Maritime Institute, Canada. He is presently vice president - marine solutions at AVEVA for the North American region. With 25 years of experience in the industry, he worked as a designer in different shipyards and in 1996 founded his ship design firm supporting different shipyards around the world from basic to production design. Before joining AVEVA in 2012, Eric was a marine surveyor at Bureau Veritas Canada for ships in service and new constructions. NA

The Story of the Kappel Propeller

Reviewed by Professor A.F. Molland

The Story of the Kappel Propeller
Written by Bruce Peter, published by Nautilus Forlag, Copehagen, 2017. 80pp, ISBN-10: 8790924673, ISBN-13: 978-8790924676, £10.00

As the title suggests this compact 80-page volume traces the history and development of the Kappel propeller. The stated intention of the book is to document the twenty five years of research going into the development of the propeller but, more importantly, to inspire readers who might be considering careers in engineering.

The Kappel propeller belongs to a generic family of propellers that have modifications to a conventional propeller near the tip of the blade. These may be tip fins, on the suction or pressure side, or modifications to the tip rake by curving the tip towards the suction or pressure side. The Kappel propeller has a modified tip rake, where the tip fin is an integral part of the blade with the blade tip smoothly curved to the suction side of the blade.

The first section of the book describes the background to the designer of the propeller, Jens J. Kappel, including his early years working for shipowners and his early interest in ship powering and propellers.

It is followed by an account of Kappel's initial research into propellers, their design and performance. Kappel had observed that in times of high fuel prices, the need for enhanced propulsive efficiency becomes clear. He had noted the parallels between marine propeller design, involving hydrodynamic theories, and those of aircraft wing design, based on aerodynamic theories. In the 1920s Prandtl and Betz had investigated optimum spanwise loadings on aircraft wings and in 1927 published the results of model tests on an experimental aircraft wing fitted with elliptical end plates, which would reduce energy loss at the wing tip.

These tests showed improved lift-to-drag ratios at higher loadings, but the advantage diminished at lower loadings due to the frictional drag of the end plates. Based on these results, and the improved theoretical work developed by Lerbs, Kappel made his first proposal for a propeller fitted with fins attached to the suction side of the ends of its blades. In the meantime, Whitcome and Cone in the USA had been investigating non-planar surfaces resulting in the development of 'winglets', fins at the tip pointing towards the suction side. Encouraged by the work of Whitcome and Cone, Kappel, together with Professor Schwaneke, designed and tested a four-bladed propeller with fins on the suction side of the blade. The original propeller produced severe cavitation, requiring a curved transition piece to be inserted. Kappel then studied aircraft wings and winglets and with support from various researchers, including T. Munk and P. Andersen, developed software for computing the optimum blade distribution for arbitrarily curved propellers. Kappel joined up again with Schwaneke and they were able to test three Kappel designs and one conventional propeller at the Berlin Ship Model Basin. The results of the tests were found to be very encouraging. The next stage would be to find a commercial partner to finance and fit a Kappel propeller to a ship for trials at sea. Discussions with various shipyards and shipowners proved fruitless.

At this stage it was decided to make an EU Fourth Framework research funding bid, by a consortium which included Kappel, a test tank, a propeller manufacturer, a shipyard, a shipowner and a university. This bid was successful and, consequently, a large section of the book is devoted to describing the cooperative research project funded by the EU research programme KAPRICCIO. This programme entailed extensive model and full scale investigations for the Kappel propeller, together with PhD students in support of the theoretical work and numerical modelling. The model propellers were tested at the Hamburg

The Kappel's distinctive blade tip curves to the suction side of the blade

Ship Model Basin (HSVA) in open water and behind conditions, together with cavitation tests to monitor the extent of cavitation . Design software was developed that would take account of the particular features of the Kappel propeller near the blade tip.

The full scale Kappel propeller was manufactured by Stone Manganese Marine (SMM). The Kappel propeller's curved tip geometry gave a number of specific manufacturing problems. These included the tip geometry being difficult to define and measure, and the curvature at the blade tip presented problems with the casting process. These problems were overcome and the first full size Kappel propeller was successfully cast by SMM.

Comparative full scale sea trials were performed on a product carrier, *Nordamerika*, with a conventional propeller and the Kappel propeller. The Kappel propeller showed an efficiency advantage of 3.5-4% over the conventional propeller. The pressure fluctuations from the passing propeller, measured at the hull, were considerably lower than from the conventional propeller, which had been demonstrated by the earlier model tank tests. It was found that the Kappel design had no negative impact on manoeuvring. The overall trials were deemed successful, and illustrated the benefits of the Kappel propeller.

After the success of the sea trials, the full commercialisation of the Kappel propeller was commenced. Kappel propellers have now been fitted to various ship types and a submarine. The design rights for the Kappel propeller, fixed and controllable pitch, have been sold to MAN Diesel & Turbo, who now market the Kappel propeller alongside its engines. To date, over 50 vessels have been fitted or retro-fitted with Kappel propellers.

The book is written in a readable manner, tells a good story, and the description of the overall propeller development process is supported by over ninety photographs, illustrating the various stages of the development of the propeller. Some actual performance characteristics for the Kappel propeller could have been added and compared with a conventional propeller. Similarly, more references, relating to the general design of marine propellers, would have been useful for the reader who wishes to pursue the subject in more depth.

The book is recommended to all those involved in the powering of ships, to those interested in the process of developing innovative artefacts and in historical developments, and those considering a career in engineering. *NA*

A.F. Molland, is Emeritus Professor of Ship Design at the University of Southampton, UK

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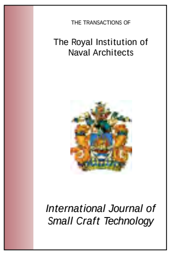

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www.workboatshow.com

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.asranet.co.uk/conferences

February 21-22, 2018
Design and Operation of Ice Class Vessels, international conference,
London, UK
www.rina.org.uk/Ice_Class2018