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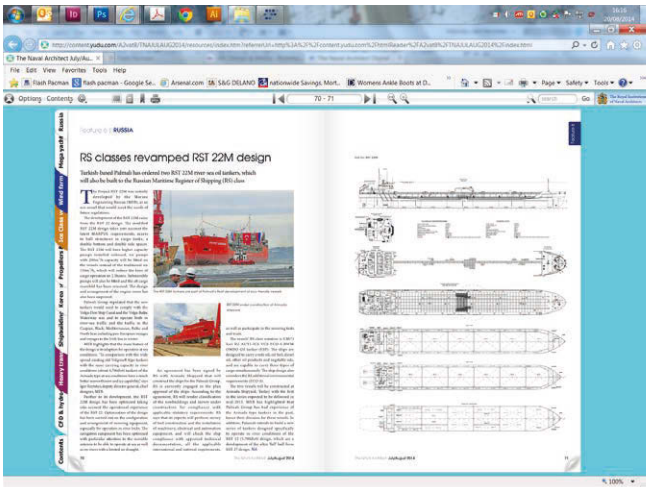

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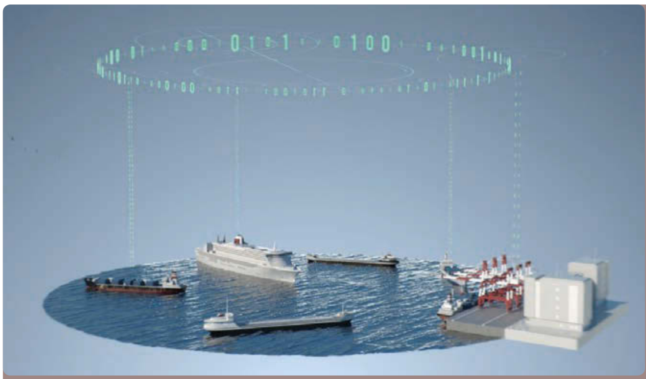


The long voyage ahead

Sea Traffic Management: a portend of a better tomorrow?

Maritime journals face a paradoxical task. On the one hand, it is our responsibility to identify the key issues facing the industry and present them concisely: a process involving some degree of (cautious) simplification. This is both for our readers' sake – to provide clarity – and our own, with word and page counts to consider.

On the other hand, we are tasked with reporting on an industry that is extremely complex. The issues with which we are concerned are thus rarely straightforward, commanding differing positions from business, legislative bodies such as IMO, Class, academic institutions, and national governments, to name just a few stakeholders. As such it is often difficult, and even inappropriate, to seek neat conclusions.

Ultimately, this tension is what makes maritime journalism interesting. To use a timely simile, it is a bit like data-driven vessel optimisation: a process of collecting all the salient information, whilst highlighting only that which provides value (and making sure it can be understood, too).

Writing as the assistant of *The Naval Architect*'s two-man editorial team who will be leaving soon for a new opportunity outside the industry, I will miss the challenge inherent in maritime journalism. The fact that I started as an almost total layman with regard to maritime matters certainly added a further layer of difficulty, although I believe this was also an asset, allowing me to engage with the issues with less of the bias that inevitably develops with time. That being said, after little more than a year I have already started to form opinions of my own, ultracrepidarian though they may be.

Looking back (and forward) I also recognise that my time on the journal has run in tandem with one of the most transformative periods in the industry's history. The reasons for this are, of course, manifold. However, in the vein of being concise, we could do worse than follow Richard Westgarth who, at a recent Immediasea roundtable, highlighted two key forces that will define this next decade of shipping: decarbonisation and digitilisation. Intricately linked, together they 'offer opportunities for the maritime industry to become safer, more efficient while at the same time reducing its environmental footprint,' claimed Westgarth's presentation.

Judging by what I have been told by a wide range of commentators and companies over the last year, it can reasonably be assumed that the maritime industry is in favour of this win-win outcome – a good thing, given that reduction of carbon emissions has been mandated by the IMO and society at large.

However, the realisation of decarbonisation and digitalisation does not look like it will be straightforward, if recent events are anything to go by. Immediately, the troubled implementation of the Ballast Water Management Convention springs to mind, as do the highly charged topics of the 2020 sulphur cap and the fitness of LNG as an alternative fuel. On the digitilisation side, advocates are regularly confronted with questions over the cyber security of connected vessels following recent high-profile attacks.

Beyond simple disagreements, the roundtable contended that a wider structural issue may be at play: the presence of silos. As previously alluded to maritime, perhaps more than any other industry, has many different stakeholders in a variety of spheres. The problem is not so much that these stakeholders come into conflict, but that they do not work in a joined-up way: 'collaboratively', in business parlance.

In real terms, this means practices such as data-sharing, which has the potential to revolutionise the provision of maritime services, optimise vessel design and create efficiencies in ports, going some way towards achieving better safety and efficiency in tandem with lowering emissions. Given that there is more data collection taking place than ever before on vessels and in large-scale studies, this potential is also growing every day. However, businesses and even institutions such as Class still hold the notion that sharing their data may put them at a competitive disadvantage and are reluctant to give too much away.

Fortunately, there is evidence that these silos are slowly breaking down. This is certainly the case internally, with cloud-based IT systems becoming increasingly common, as well as third-party platforms such as DNV GL's Veracity. Externally, projects like the EU co-funded Sea Traffic Management (STM) initiative are evidence of progress. Comprising of numerous partners from across industry, the project is looking to incite widespread real-time data exchange between vessels and shore-based stakeholders to enable reliable just-in-time arrival, ship-to-ship route exchange and enhanced winter navigation. According to the project's website, this could in sum reduce emissions by 7%, which is a significant number given that the architecture for data exchange is already available, if not the willingness.

Although I will no longer have the same 'insider access', I will continue to follow the progress of an industry seemingly on the brink of great change. One thing I am certain of is that if the ideas of just some of the many dedicated people in the industry come to pass, maritime has a brighter, greener future ahead. *NA*

Joseph Stewart, Editorial Assistant

Green fuels

Liquefied hydrogen bunker vessel concept unveiled

Norwegian engineering firm Moss Maritime, in cooperation with energy company Equinor, operator Wilhelmsen and class society DNV GL, has developed a concept design for a Liquefied Hydrogen (LH2) bunker vessel.

The project, which has been sponsored by Innovation Norway, was launched with the objective of clarifying the challenges and identifying solutions to hydrogen storage and handling. The resulting design is aimed at both providing bunkering services to future hydrogen-powered ships and open sea transportation.

The LH2 bunker vessel, which has a cargo capacity of 9,000m^3, utilises a cargo containment system to maximise insulation, storing the liquified hydrogen at a temperature of -253°C. Tor Skogan, vice president LNG for Moss Maritime, said the project builds upon Moss's experience in designing Moss LNG carriers, adding that there are cost advantages compared to pressurised hydrogen gas systems.

Håkon Lenz, VP Europe and Americas, Wilhelmsen Ship Management, said: "We see hydrogen as a possible fuel for the future. The commercial feasibility of such a vessel is depending on the overall hydrogen market development. Once market signals show that there is a need for big scale liquefied hydrogen, we and our partners are ready to take this design to the next level."

The LH2 hydrogen bunker vessel concept

Ro-ro's

DFDS takes delivery of *Gothia Seaways*

The vessel is one of six for DFDS that will be built to Knud E. Hansen's design

Danish freight operator DFDS took delivery of *Gothia Seaways*, the first in a series of six identical ro-ro cargo carriers, on 31 January. The 15,930dwt, 6,700 lane metre (450 trailer) vessel, which is 237.4m long and 33m wide, will operate on a route between Istanbul and Trieste from March.

Ordered from China's Jinling Shipyard in 2016 and designed by naval architects Knud E. Hansen, *Gothia Seaways* is powered by MAN B&W 8S50 ME-C main engines each with an output of 11,800kW and has a service speed of 21knots. The ship and its sisters will be the first DFDS vessels built to IMO's EEDI standards and the operator claims they will be the most efficient in its fleet. The high number of lane metres across its five decks also necessitated a unique ramp system in the vessel's design so that it can be loaded and discharged within a short timeframe.

The name *Gothia Seaways* is expected to be only temporary as the vessel will ultimately operate as part of the fleet run by Turkish-owned Mediterranean shipping group U.N. Ro-Ro, which was acquired by DFDS in April 2018. As such, the vessel's livery will be repainted and the vessel will transfer from the Danish to Turkish registry.

Ship recycling

Turkey ratifies IMO's Hong Kong Convention

Turkey has become the seventh country to ratify The Hong Kong International Convention (HKC) for the Safe and Environmentally Sound Recycling of Ships, the legislation drawn up by IMO in 2009 covering the environmentally sound design, construction, operation and maintenance of ships, and preparation for ship recycling.

The Convention requires ships sent for recycling in a signatory country to carry an Inventory of Hazardous Materials specific to that vessel. In addition, the authorised recycling yard must carry a Shipyard Recycling Plan, specifying the method by which that ship will be recycled, dependent upon the inventory.

Belgium, Congo, Denmark, France, Norway, and Panama have all previously ratified the HKC and, with the addition of Turkey, the states now represent 20% of the world merchant gross tonnage. The HKC will be formally triggered when 15 nations, representing 40% of global tonnage have ratified it. However, what is more significant is that Turkey is also one of the world's five major ship recycling countries, along with Bangladesh, China, India, and Pakistan, which between them account for 90% of all recycled vessels.

The poor social and environmental conditions at shipbreaking facilities has long been a subject of intense debate. Since 31 December 2018, the European Union has mandated that large merchant vessels bearing the flags of members states must be recycled at one of the 23 yards included on the European List of ship recycling facilities, of which two are in Turkey.

Speaking to *The Naval Architect*, the NGO Shipbreaking Platform, which has long campaigned against human rights abuses and environmental harm, pointed out that by meeting the EU's stringent requirements Turkey already follows higher standards than required by the HKC. Moreover, it emphasised its long-held belief that the HKC is not an adequate solution given the proliferation of HKC Statements of Compliance to what it deems substandard facilities.

LNG carriers

LNG carriers top huge CSSC contract

China State Shipbuilding Corporation (CSSC) has announced it has sealed contracts for 36 newbuildings to the value of RMB10 billion (US$1.48 billion), including two plus two 174,000m^3 capacity LNG carriers to be built by Hudong Zhonghua Shipbuilding.

The contract, which is financed by CSSC's leasing subsidiary CSSC (Hong Kong) Shipping Company, also includes eight heavy-lift vessels, four 300,000dwt VLCCs and 20 feeder container ships. A letter of intent has also been signed for four 95,000dwt bulk carriers and a number of fishing vessels.

The LNG carriers, which have been ordered by Mitsui OSK Lines (MOL), further consolidates Hudong Zhonghua's position as the leading builder of LNG carriers, a market once dominated by Korean shipbuilders. To date it has built more than 20 large-scale LNG carriers. The newly contracted vessels will be to Hudong Zhonghua's 'fourth generation' design, utilising dual-fuel propulsion from twin WGD6X72DF low-speed engines.

Cruise ships

Lawsuit filed against Carnival for listing ship

Three passengers who sustained injuries when the cruise ship *Carnival Sunshine* briefly listed due to a technical malfunction in October 2018 filed a federal lawsuit in Florida in January.

The plaintiffs allege that Carnival was negligent in training its staff and maintaining the ship, which tilted on its side for a period of 60 seconds shortly after leaving Port Canaveral, Florida. Passengers reported widespread panic as glasses and silverware fell from tables and shattered around them.

Carnival Sunshine

In a formal statement later that day, the ship's captain told passengers: "We have identified that an electrical switchboard malfunction impacted the use of the fin stabilizers. It's important to note that fin stabilizers are not a safety feature; they are deployed solely for guest comfort to minimise any potential ship motion while at sea. There was never any issue with the safe operation of the ship and our officers quickly intervened."

Carnival Sunshine completed the rest of its journey to Amber Cove in the Dominican Republic without further incident. Built in 1996, and originally named *Carnival Destiny*, *Carnival Sunshine* is the lead ship in Carnival's Sunshine-class of cruise ships.

Automation

Report tackles automation's impact on workforce

A report jointly published by the International Transport Workers' Federation (ITF) and the World Maritime University (WMU), has concluded that the introduction of automation in global transport will be "evolutionary, not revolutionary".

'Transport 2040: Automation Technology Employment – the Future of Work' explores how the global transport industry will change with the introduction of advanced technologies, forecasting and analysing trends and developments across sea, road, rail and aviation. With regard to maritime transportation, the report looks at 17 countries to assess their levels of preparedness for technological innovation.

Speaking at the official launch of the report on 15 January, IMO Secretary-General, Mr. Kitack Lim, was keen to emphasise that integrating new and advancing technologies into the regulatory framework of the shipping industry is one of IMO's key strategic directions. "Member States and the industry need to anticipate the impact these changes may have and how they will be addressed," Lim stated. *NA*

Opportunities and obstacles – looking to 2050

Malcolm Latarche on the implications of two new reports published on the pathway to decarbonisation and the future of the maritime industry

January is traditionally the month to look ahead and try to set some goals for the future and although its more usual to do so at the beginning, two reports issued in the last week of the month have sought to predict what ships and shipping may look like for the next generation.

Arguably, the IMO started the ball rolling last year with its roadmap for decarbonising shipping and that is the also the focus of *Zero-Emission Vessels Transition Pathways,* a joint study by Lloyd's Register (LR) and University Maritime Advisory Services (UMAS). The other is a report by the UK Department for Transport (DfT) titled *Maritime 2050: Navigating the Future*, which also includes the issue of decarbonising shipping but is much wider ranging and which seeks to explore and promote the UK's potential in seven areas: competitive advantage, environment, infrastructure, people, security, technology and trade.

Even before the IMO's ambitious plans were adopted at MEPC in April last year there had been years of discussion documents, reports and studies around the subject of emissions and decarbonising shipping. With the EEDI rules there is even an element of decarbonising newbuildings already in place.

The LR/UMAS document says that: 'To achieve the level of ambition of at least 50% reduction in GHG emissions by 2050, zero-emission vessels need to be entering the world's fleet in 2030. At this point in time, there is too much uncertainty to decide on one route for the future transition of the shipping industry. So, to reduce uncertainty, one way is to look at future projections and explore the potential of a combination of different technologies and fuels'. The document then looks at three key primary energy sources that would allow zero-carbon fuels to enter the shipping fuel market; renewable energy, bio-energy and fossil fuels with carbon capture and storage (CCS).

So far, the necessary movement to find new fuels has not really got underway. LNG, which has been pushed hardest, has taken almost 20 years to go from nowhere (excluding LNG carriers running on boil off gas) to around one per cent of the world by ship numbers. More to the point, most of the growth in LNG-fuelled ships was more related to NOx reduction than CO_2 reduction. Even the latest upward trend for LNG-fuelled ships is driven by the need for reducing SOx emissions after 1 January 2020 than by decarbonisation.

The impending sulphur cap might well be the biggest spur for switching from oil fuels to LNG but even here it would seem that scrubbers which allow continued use of HFO are proving more popular than LNG. There seems to be no slowing in the surge of scrubber orders despite recently announced bans on using open-loop scrubbers in Singapore, some Chinese waters and Fujairah.

From an economic point of view, switching from HFO to low sulphur MDO for the short journey from the open sea to berth in ports with scrubber bans will hardly damage the economic case for scrubbers. It may slow the payback period by a month or so but little else. Environmentally, scrubbers promote the continued use of oil fuels.

Decarbonisation is mentioned in the DfT report but it is not the main thrust of the document. The report on the country's role in the world of shipping is apparently the first of its type that any UK government has produced. At 338 pages it is a lengthy read and has most likely been timed to put a positive slant on what the UK may or may not do once it leaves the EU.

There is a great deal of optimism in the report and a clear determination for the UK to regain some of its lost influence in the maritime arena by drawing on areas where it is still strong and redeveloping others. When – some may say if – the UK does leave, it could capitalise by dropping some of the more onerous EU regulations that apply to ships flagged in EU states and to ships calling to EU ports.

As well as talking up the positive aspects of UK shipping in many areas such as training, technology and safety, the report also highlights that there is a shift in the world economy eastwards and new emerging markets will have a significant impact on the maritime sector. It warns that with a potential shift in political power bases there could be a change in rules-based discussions in the IMO and other international fora. According to the report, the UK intends to strengthen its position in the regulatory arena and remain as host nation to the IMO. It is not revealed whether the potential shift in political power bases mentioned refers to China's growing influence or the US and Brazil's changing views on the Paris Agreement. NA

Performance monitoring

StormGeo and DNV GL to partner on fleet performance solutions

Class society DNV GL and route optimisation specialists StormGeo have signed an agreement to consolidate their fleet performance solutions under a single banner, it was announced in Oslo on 7 February.

The agreement will see DNV GL's ECO Insight and Navigator Insight solutions fused with StormGeo's FleetDSS and ship reporting solutions to create a new offering that will be developed, managed and sold by StormGeo. The two companies claim the consolidation creates the largest vessel performance data set in shipping, with a combined fleet of more than 12,000 vessels that will receive a daily service from StormGeo in route advisory, weather intelligence, navigation and planning or fleet performance.

Per-Olof Schroeder, CEO, StormGeo, said: "Partnering with DNV GL enables us to accelerate the development of our fleet performance management offering by pooling the competence, software, and insight of both companies.... Bringing these solutions together will give our clients even more ways to enhance the safety, efficiency, and transparency of their operations."

DNV GL, which has held a 26.4% stake in StormGeo since 2014, will remain strongly involved with the new offering, as well as continuing technical support to its ECO Insight customers. Users will also able to share data through Veracity, DNV GL's open industry platform.

www.stormgeo.com

StormGeo's CEO Per-Olof Schroeder with Trond Hodne, SVP at DNV GL

Ballast water treatment

Bawat ballast system on brink of USCG approval

Danish ballast water treatment specialist Bawat is on the verge of achieving full US Coastguard (USCG) approval for its unique pasteurisation-based system, the company reports.

As covered in *The Naval Architect* in April 2018, Bawat's system utilises scavenged heat generated from the ship's engine and other onboard systems to eliminate or neutralise invasive species. The process has been proven to be effective at temperatures as low as 64°C, without the need for chemicals, filtering or UV radiation. The system is also cheap to install and maintain as it can be largely built from standard components, with Bawat earning its money through the proprietary temperature control system.

The company has also been developing a mobile containerised 'plug-in' solution whereby whereby vessels can treat their water portside. It is designed for vessels that may be experiencing problems with their installed system or even, in some cases, not installed a system at all.

Bawat CEO, Kim Diederichsen, explains: "As long as the water is treated according to regulations then vessel operations are compliant. That doesn't necessarily mean ships have to install systems themselves – why not utilise a reception facility instead?"

In other ballast news this month, class society ABS has been revealing some of the key findings of questionnaires and workshops for shipowners and operators, concerning the challenges they are encountering with ballast water treatment systems. These included:

- Incorporating ship-specific contingency measures within the BWM Plan to avoid downtime and penalties
- The need for system-specific training, both for shoreside support and ship crew
- Monitoring key data and operational trends and system design limitations to determine the suitability of the treatment technology for a vessel's planned operational routes
- Better after-sales global support and expertise from manufacturers

The results of these discussions are also intended to inform an updated version of ABS's Best Practices for Operation of Ballast Water Management Systems Report, which is due for publication shortly.

www.bawat.com
www.eagle.org

Engines

MAN LPG engine to power Chinese VLGC

MAN Energy Solutions is celebrating after winning an order for its LPG-burning MAN B&W 6G60ME-LGIP engine from Jiangnan Shipyard, a subsidiary of China State Shipbuilding Corp (CSSC).

The engine will be installed onboard a 86,000m^3 VLGC (Very Large Gas Carrier) the yard is building for Chinese operator Tianjin Southwest Maritime (TSM) and scheduled for delivery in the second half of 2021.

MAN B&W's 6G60ME-LGIP is proving a hit for tankers and VLCCs

The contract also includes an option for a second vessel.

It follows orders last year for the same engine for two similar-sized vessels that Hanjin Heavy Industries is building for Belgian gas company Exmar and reflects growing interest in LPG as a price competitive, sulphur-free fuel.

Launched in Copenhagen in September 2018, the ME-LGIP (-Liquid Gas Injection Propane) engine is an evolution of its earlier ME-GI and ME-LGI dual-fuel engines. The Diesel principle is said to provide the ME-LGIP with high operational stability and efficiency, including during load changes and fuel change-over. MAN also reckons it to be the most environmentally friendly, two-stroke technology available with negligible gas slip.

Bjarne Foldager, Head of Two-Stroke Business at MAN Energy Solutions, added: "In gas mode, the ME-LGIP engine operates on just 3% pilot oil and down to 10% load. Ultimately, we expect the engine to operate without the need for pilot oil."

www.man-es.com

Coatings

Number of Selektope coated ships could double in 2019

Swedish biotech firm I-Tech AB says the largest ever single volume order received for Selektope, coupled with strong commercial developments in late 2018, will see the number of ships using its barnacle-repelling antifouling ingredient in coatings more than double this year.

Developed by I-Tech, Selektope is an ingredient for marine coatings that repels barnacles from the hull by temporarily activating the swimming behaviour of barnacle larvae, making it impossible for them to settle on the hull surface.

A supply order placed by one of the industry's leading marine coating manufacturers, Chugoku Marine Paints (CMP), in December 2018 will be delivered during 2019 for use in CMP's range of existing coating products containing Selektope that target both new building and dry-docking demands.

With global biofouling hotspots intensifying as a result of oceanic warming, the impact of biofouling on the profitability of a ship operations will continue to generate an indefinite commercial headache for operators. Adding to these well-known financial impacts, there is also growing regulatory movement against the transportation of invasive aquatic species (IAS) by the international shipping fleet via hulls, both on a regional and international level.

www.selektope.com

Performance monitoring

Eniram rolls out SkyLight 3.0

Wärtsilä subsidiary Eniram has released a significant upgrade to subscription-based fleet performance monitoring service Eniram SkyLight. The latest iteration, Eniram SkyLight 3.0, includes mobile notifications and virtual propeller RPM sensing.

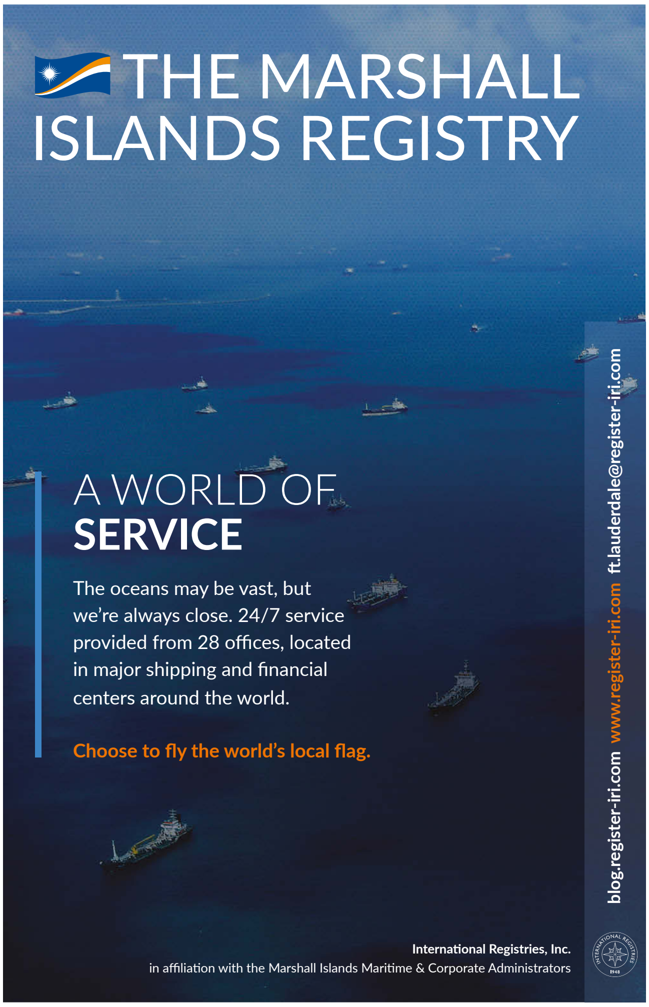
This propeller sensing is achieved without requiring integration with other ship systems and the information it provides will also be used to further improve the accuracy of the speed/fuel curve calculated by Eniram SkyLight 3.0.

Eniram has also announced a partnership with insurance data analytics company Concirrus, that will see navigational and situational data provided by SkyLight 3.0 integrated into Concirrus' marine insurance underwriters' application Quest, allowing marine insurers real-time risk management.

"By working together, and through the integration of our products, we shall deliver the world's first connected marine insurance proposition. It will lower operating costs by actively monitoring vessel performance, by allowing insurers to reduce premiums accordingly, and by providing visibility of the insurance policy conditions and compliance to both shore and ship," proclaimed Eniram's managing director Johan Backas.

www.eniram.fi

Eniram SkyLight 3.0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Maritime industries to face new tunes in digitalisation

Volker Bertram, Dept. Mechanical and Mechatronic Engineering, University of Stellenbosch, gives his unique take on what participants can expect at this year's conference on Computer Applications and Information Technology

Digitalisation (a.k.a. Digital Transformation and Digitisation) is a magic word in our times. While there is no clear definition of what exactly is 'Digitalisation', the general idea is widely understood and shared: it concerns the next wave of automation, not just increasing efficiency but also offering new and better services – in theory at least. And all companies in the industry want to be part of it and 'do it'. You may not like it, but resistance is futile – get digital!

The maritime industry upgrades to the next level of IT technology. Source: Siemens

Wind of change

Our industry has been using computers for a long time. In fact, ship stability calculations were among the first large-scale industrial computer applications. So what is the fuss about? In many cases, it is about an upgrade to the next level of IT technology. Call it computer-aided design 4.0. The 'computer' turned into MPC (massively parallel computing): 'PDM' (product data models) and 'simulations' talk to each other and get updated in time, and – lo and behold – we have the 'Digital Twin'. And should we pretend to understand all of this, we then adopt new cryptic abbreviations, calling a Digital Twin a DT and the Internet of Things IoT. But behind the smoke screen of new terminology and abbreviations, there are sensible concepts and solid engineering to offer us better tools. No need to be unduly impressed, but we would be foolish not to follow up on the new possibilities.

Henrique Gaspar's (NTNU) perspective on the past, present and future of computer-aided ship design reminds us of how many problems we have solved already – and how many new problems we created in the process. Fortunately, he remains optimistic for the future which will see "smart computer-aided systems in ship design, merging artificial intelligence [and simulation] models and open access to ship design data." This seems to echo a wider sentiment in the industry. "There are many aspects in which Artificial Intelligence can be applied in ship design, [… e.g.] learning as you go through the design[s]," confirms Rodrigo Perez (Sener). Indeed, the potential applications are manifold, and akin to yesterday's use of statistics or – even more old-fashioned – experience in designers, surveyors, etc. Machine learning and data mining used to be called computational statistics, but the new terminology is much catchier, and the applications outperform yesterday's software solutions.

Besides the old problems that we solved, and the new problems that we created in the process, there is a third class of problems: those that seem to be eternal. Foremost among these are interface problems. The industry has given up the illusive dream of the one software that will bind them all, the cathedral solution, or in IT new-speak the 'best of suite'. Instead, 'best of breed' is the new banner we all follow. Best of breed means that we have a multitude of software from different vendors, all best for their specific purpose, but generally all with their own data formats. Plugging them together has been a traditional nightmare, but solutions start to evolve thanks to open formats and automatic data conversion techniques, claims Joanna Sieranski (Prostep).

It ain't me, babe?

While we might think first of Industry 4.0 or autonomous ships, the digital transformation affects virtually every branch and everybody. Resistance may be futile, but it is commonly practiced in some niche areas. But it ain't me, babe, no, no, no, says for example the teacher (professor). But, yes, yes, yes, babe! Plumbers and cooks may be safe from the digital transformation, but disruption is in the air for the training departments. A new universe of digital training solutions is opening up. Tracy Plowman (DNV GL) offers a hitchhiker's guide to it, pointing out that its exploration may cost more (initially) than most of us thought. The trend is towards combining digital training technologies, such as

'classical' e-learning with simulation-based exercises, notes Volker Köhler (benntec). Woo-Sung Kil (Korean Register) gives us a glimpse of might be in store in years to come, with multi-participant crew emergency response training in Virtual Reality. Raal Harris (KVH Videotel) sees Virtual Reality as a potentially "game-changing disruption" in training, but points out that there are assorted challenges and obstacles. The times, they are a-changin', also or perhaps especially in maritime training.

Virtual Reality is in the limelight not just for the maritime training community, but also the ship design community. Here the common thread is "communicating ship designs via Virtual Reality" (Hans van der Tas [DEKC Maritime]). Talk to me like lovers do. And it seems as if the idea of using VR as a communication belt for design ideas was in the air in London, Copenhagen, Perth and Groningen. Ship designers from different parts of the world and with different ship types in mind have come independently to the same conclusion: "Virtual reality tools allow better engagement of stakeholders in the concept design. The immersive and realistic nature of VR enables people to experience a design with exceptional realism" (Kenneth Goh [Knud E. Hansen]). I can see clearly now, not just on aesthetic aspects of design, but also on functional aspects such as visibility and reachability.

Virtual Reality – More than a game for ship designers by now. Source: SSI

Come together, right now

If the Digital Transformation is a (long) journey, why have so many in our industry the impression it is happening "now"? As with most complex questions, there is no single answer. But Denis Morais (SSI) has shed some insight in his many contributions and Lighthouse blog: The technologies have been around for years, if not decades, but now they come together to mature applications. And they need to come together with other technologies to offer powerful solutions. Without fast internet, no Big Data. Without Big Data, no sense in machine learning, etc., etc.

There are countless examples of how technologies are combined to make our lives easier in ship design and ship production. For example, Christian Cabos (DNV GL) combines drone technologies (flying by and taking photos and videos of ship structures, avoiding expensive scaffolding) with image processing by A.I. Having been trained on thousands of images with and without cracks, the computer learns to identify cracks in various lighting conditions. Sure, A.I. is not any cleverer than human surveyors, but getting to be almost as good in identifying cracks and so much faster. Aye, aye, A.I. You convinced me.

You ain't seen nothing yet

The Digital Transition is exactly that – a transition. There is no single point in time where we can pinpoint that we turned digital. It is a lengthy and continuous process. We have come a long way and we still have a long way to go. But we are getting there. The visions are there, and the stakeholders work together to turn them into reality. For example, Ludmila Seppälä (Cadmatic) sees a "future of drawing-less production in shipbuilding projects", extrapolating from 2D CAD of the past over the 3D CAD (expressed often in 2D drawings) to a 2050 vision of ship and generally maritime production. Now here's a vision. And advanced shipyards already "conceptualise the idea of the digitalised yard of the future", argues Per Olaf Brett (Ulstein).

And the road goes on forever

The names referenced here point to papers in COMPIT 2019. If you cannot make it to follow the key trends in maritime IT, downloading the proceedings freely from www.compit.info will allow you to stay in tune. And with the Digital Transformation, the road goes on forever and the party never ends… *NA*

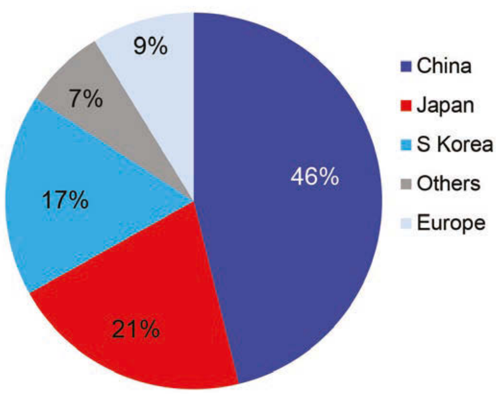
High-performance computing has entered everyday design practice. Source: Altair

Clarkson Research Services: Historic and Scheduled Delivery

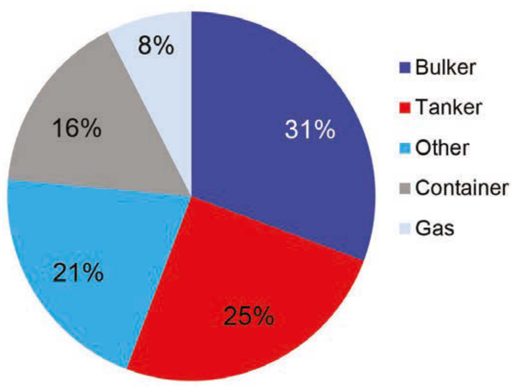
Data extract from World Fleet Register available at www.clarksons.net/wfr

Vessel Type	2007		2008		2009		2010		2011		2012		2013	
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half
VLCC >= 200,000	15	14	8	23	32	20	30	24	35	27	27	22	21	9
Suezmax 125-200,000	15	11	8	5	23	22	26	11	26	18	30	15	23	4
Aframax 85-125,000	29	27	26	42	63	33	39	31	28	31	30	15	14	6
Panamax Tankers 55-85,000	28	15	17	26	26	12	15	16	19	10	9	6	7	5
Products 25-55,000	72	70	73	92	92	67	66	46	45	27	27	30	49	29
Products 10-25,000	10	9	8	5	5	5	7	6	8	6	13	5	9	4
Chem & Spec. 10-55,000	59	62	83	103	106	69	76	60	53	41	39	9	8	13
Tankers < 10,000	32	47	60	92	71	70	65	50	53	51	69	34	36	28
Capesize > 100,000	31	26	21	24	33	77	101	112	128	122	149	65	63	40
Panamax 80-100,000	22	16	15	17	27	21	60	61	81	97	140	94	101	68
Panamax 65-80,000	22	22	23	20	18	15	18	33	36	44	53	39	34	42
Handymax 40-65,000	49	50	66	61	84	100	168	166	199	198	228	146	147	119
Handysize 10-40,000	47	64	75	75	119	156	163	169	173	172	221	116	115	80
Combos > 10,000	0	0	0	0	0	0	3	2	3	0	0	0	0	0
LNG Carriers	16	16	25	26	22	17	15	12	5	10	1	2	4	13
LPG Carriers	16	20	27	33	25	18	18	18	16	14	13	8	22	16
Containers > 8,000 teu	21	17	25	26	21	14	29	33	48	30	51	28	51	33
Containers 3-8,000 teu	58	73	69	62	59	59	77	41	31	21	39	19	46	29
Containers < 3,000 teu	106	123	137	109	69	53	54	26	33	30	33	38	29	17
Offshore	3	16	15	16	11	19	22	25	28	23	30	10	12	19
Cruise Vessels	7	3	6	3	3	6	9	4	4	2	6	1	6	0
Passenger Ferries	15	10	21	7	11	8	10	13	11	10	11	8	6	6
Other	138	138	155	155	152	162	172	181	182	182	189	99	97	79
TOTAL	**811**	**849**	**973**	**1,022**	**1,072**	**1,023**	**1,243**	**1,140**	**1,245**	**1,166**	**1,408**	**809**	**900**	**659**

Orderbook by builder region (number of vessels)



Orderbook by sector (number of vessels)



2014		2015		2016		2017		2018		Scheduled Orderbook		
1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	2019	2020	2021
14	10	9	11	23	24	29	21	21	18	65	32	2
4	4	7	3	8	19	35	22	25	7	32	27	5
4	13	22	10	31	22	36	28	26	24	68	25	17
3	1	2	1	7	13	10	11	7	6	16	16	8
49	49	60	57	60	42	39	25	27	22	112	46	5
1	8	4	0	3	2	6	4	8	3	20	8	0
12	11	36	29	43	36	38	31	45	40	63	31	2
25	22	12	14	25	15	24	28	40	30	50	11	3
56	38	46	42	65	39	55	20	30	21	86	100	25
62	35	57	41	71	40	75	27	39	25	141	91	14
42	20	19	4	1	2	6	1	2	0	2	6	0
98	101	144	121	124	94	124	54	57	30	116	85	21
96	67	100	83	84	45	68	29	47	38	82	36	3
0	0	0	0	0	0	0	0	0	0	3	3	0
14	19	16	16	15	18	20	12	32	23	44	47	38
14	14	25	40	49	33	45	17	26	10	35	33	0
59	42	58	62	37	26	34	36	47	23	54	56	31
26	25	18	6	2	0	2	5	7	3	7	11	0
22	27	27	35	39	25	36	40	48	31	128	113	20
32	30	25	14	25	21	18	24	25	11	43	42	15
3	2	5	1	8	2	7	3	8	5	23	24	16
12	8	13	8	6	16	21	10	10	18	48	29	7
72	62	67	47	50	58	44	55	44	44	189	67	12
720	**608**	**772**	**645**	**776**	**592**	**772**	**503**	**623**	**432**	**1,427**	**939**	**244**

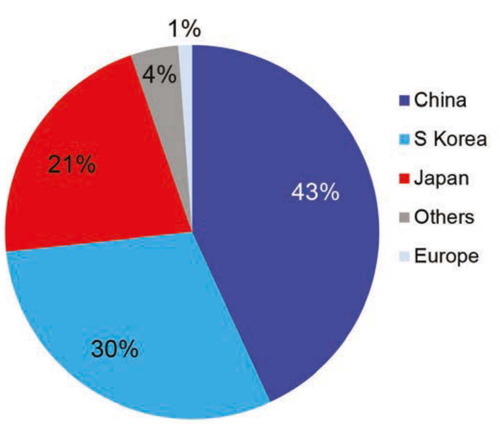
Data includes all vessels with LOA estimated at >100m

Where scheduled month of delivery is unknown an arbitary month of build has been applied for orderbook data

The orderbook by year of delivery on this page is based on reported orders and scheduled delivery dates and do not necessarily represent the expected pattern of future deliveries

All data taken as of 1st January 2019

Orderbook (DWT) by builder region



Source:
Clarkson Research Services

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SHIP ECONOMY & TRADE

Delivery of the world's first VLCC with 'windsurfing' installation

Deploying energy-saving hard sail technology, *New Vitality* was delivered to owners China Merchants Energy Shipping late last year

New Vitality

Built by Dalian Shipbuilding Industry Group Co., Ltd. (DSIC), China Merchants Energy Shipping (CMES) took delivery of *New Vitality*, the world's first 308,000-ton capacity very large crude carrier (VLCC), on 13 November 2018. The application of a sail to the VLCC represents the first project of its kind in China. From the perspective of the size of the sail prototype and the tonnage of the ship, it also fills an international gap.

The sail mounted on the *New Vitality* is 39.68m high and 14.8m wide. The maximum outer diameter of the rotary base is 5.3m, and the middle cylinder of the base is 4.5m. The unit consists of a slewing mechanism, a mast and a sail wing. According to DSIC, analysis of sea trial data from *New Vitality* shows that the airfoil's propulsion boosting effect meets design expectations whilst the energy saving effect goes beyond these. This indicates that the domestic R&D team led by DSIC has successfully mastered the key technologies of airfoil development, design and manufacture, and completed the engineering application of wind propulsion on a VLCC. "I believe that in the context of global energy conservation and emission reduction, energy-saving technologies such as [wind] will be promoted and applied on more large ships," said a spokesperson.

Multi-party cooperation

The 'Sailing Technology Demonstration Application Development' project that spawned the sail is an innovative key project approved by the Ministry of Industry and Information Technology of China for energy conservation and emission reduction. It was organised by China Shipbuilding Industry Corporation (CSIC), and led by DSIC, CMES, China Ship Scientific Research Center (CSSRC), and China Classification Society (CCS). Many organisations including the Shipbuilding Engineering Society (CSNAME), Dalian Maritime University, and Dalian University of Technology participated in the project. Since the launch of the project in 2015, DSIC has actively organised research institutes to carry out research, demonstration, calculation, testing, analysis, etc., and has created successful cases of collaborative innovation. Among them, China Merchants Steamship, as the owner of the project, actively promotes the research and application of new smart and green technologies, and provides feasible solutions and ideas for project research and development.

DSIC designed the sail device, the structure/hydraulics related to the actual ship, and the electrical system, with work carried out into the sail airfoil research and development design, hydrodynamic analysis and model test; CCS carried out various risk assessments and drawings review of the project.

Construction process

Since the start of the sail prototype on 1 September 2017, DSIC has led the organisation of the domestic superior team, from sail airfoil design and hydrodynamic analysis to structural, hydraulic and electrical design, under the careful organisation of CSIC. It then carried out research, demonstration, calculation, testing, review and analysis, and successively overcame a large number of technical problems such as the development of process technology, process flow, process equipment, etc.

In August, the first sail prototype was successfully developed and the roadbed test was successfully completed. From 20 to 24 October, after five days of sea trials, the project successfully completed the sea trial mission. The test included a sail warning point and control system test, sail demonstration test, sail manoeuvre performance test and sail boost (including EEDI) test. The success of this sailing test proves that the airfoil sail scheme is effective, and the effect of wind boosting super-large vessels is remarkable. In the context of global energy conservation and emission reduction, wind resources will be promoted and applied on more ships as an important means of energy conservation and emission reduction.

DSIC is the first shipyard to build a VLCC in China and one of the key shipyards in the country. In recent years, DSIC has developed six generations of its 'Type 8' model and has received a total of 93 orders. The number of constructions has accounted for more than 10% of the global VLCC fleet, giving DSIC a worldwide reputation. *NA*

Tailored to the tropics

Tropical Shipping's new feeder vessel, *Tropic Hope*, is of a carefully considered design notable not for its novelty but for how well it responds to its owner's specific needs

Much like there only ever seems to be bad news in the papers, it can seem like the only vessels that get coverage in the maritime media are either the leviathans, those that are particularly green, or so-called 'autonomous' ships. While the interest and importance of such vessels is clear, their domination of the column inches means that vessels without such features – which may in fact be very interesting for other reasons – receive little fanfare.

Where these seemingly ordinary vessels stand out tends to be how well their design responds to their intended operational profile. Rather than multipurpose, such vessels are designed and built to serve a specific route carrying particular cargoes (or people), doing so in the most efficient manner whilst meeting local and national regulations.

Ultimately, these workhorses are the most valuable vessels in their owner's / charterer's fleet because they perform their intended role reliably and economically, often enabling the fulfilment of long-term contracts. They are therefore less affected by commercial trends, helping to secure the bottom line when other vessels are out of action due to a lack of demand or overcapacity.

A significant ship

For these reasons, RINA's *Significant Ships* series attempts to highlight some of these vessels alongside the big names readers will likely already be familiar with. One such example from the 2018 edition, publishing this month, is *Tropic Hope*, a 159m, 1,148teu feeder container ship designed by the Shanghai Merchant Ship Design & Research Institute of CSSC (SDARI), built at Guangzhou Wenchong Shipyard in China, and owned/operated by Florida-headquartered Tropical Shipping. It is the first of four in the company's new Carib class, giving a clue as to its intended deployment connecting Halifax, Palm Beach, Fla., Puerto Rico, the Eastern Caribbean and the Virgin Islands.

Tropic Hope from the starboard side

Although relatively small by modern standards, *Tropic Hope* is larger than Tropical Shipping's oldest vessels dating from the late 70s and early 80s, which fall between 79 and 90m; moreover, despite being similar in length to 2001's *Tropic Carib* and *Tropic Unity*, the vessel has over 100 extra teu capacity. The size perfectly suits the requirements of a regional container line operation, allowing access to smaller but crucial ports.

"Where these seemingly ordinary vessels stand out tends to be how well their design responds to their intended operational profile"

Specifically, *Tropic Hope* (like other Tropical Shipping vessels) is a 'reefer carrier,' meaning that it can accommodate refrigerated containers for cargoes requiring temperature control – especially pertinent in the hot climate of the Caribbean. To enable this, the vessel is fitted with a total of 260 'reefer plugs,' which provide power to the containers' cooling systems both at sea and in harbour. The plugs are sited on deck and in the holds, allowing reefer stowing in up to two tiers on deck and four tiers underneath.

Adapted to the Americas

The design of the vessel also responds to the non-standard container sizes used in the Americas, which include 45' and 49' units. The former can be carried on the lift-away pontoon hatch covers from the third tier, whilst both can be carried on deck. Another anomaly in the Americas

TECHNICAL PARTICULARS	
Tropic Hope	
Vessel type:	Container ship
Length (oa):	159.73m
Breadth moulded:	24.50m
Depth, to main deck:	14.80m
Deadweight, design:	13,038dwt
TEU capacity:	1,148
Complement:	7 officers, 14 crew

is the use of 40’ (and more rarely 45’) ‘high-cube’ containers that are 9’6” tall as opposed to the usual 8’6”, which can be accommodated in the cargo hold. Moreover, *Tropic Hope* is fitted on the port side with two MacGregor 45-tonne cranes of the electro-hydraulic cylinder luffing type, to enable container transfer at some of the less well-equipped ports of call on the vessel’s route.

When it comes to power and propulsion, *Tropic Hope* runs on HGO or MGO burned by a single-acting two- stroke low-speed MAN B&W 6S60ME-C8.5 engine. This delivers a high service speed of 20knots which, according to designers SDARI, ‘is quite unique against the background of the growing requirements of the energy efficiency design index.’ A further notable feature is that the shaft generator, with a power take in arrangement, also acts as an emergency take home system.

The vessel also has both a bow and stern thruster manufactured by Brunvoli, providing the high level of manoeuvrability needed in more diminutive ports such as Saint Kitts and Saint Thomas in the US Virgin Islands. A controllable pitch propeller and Becker twisted trailing edge rudder further enhance this quality.

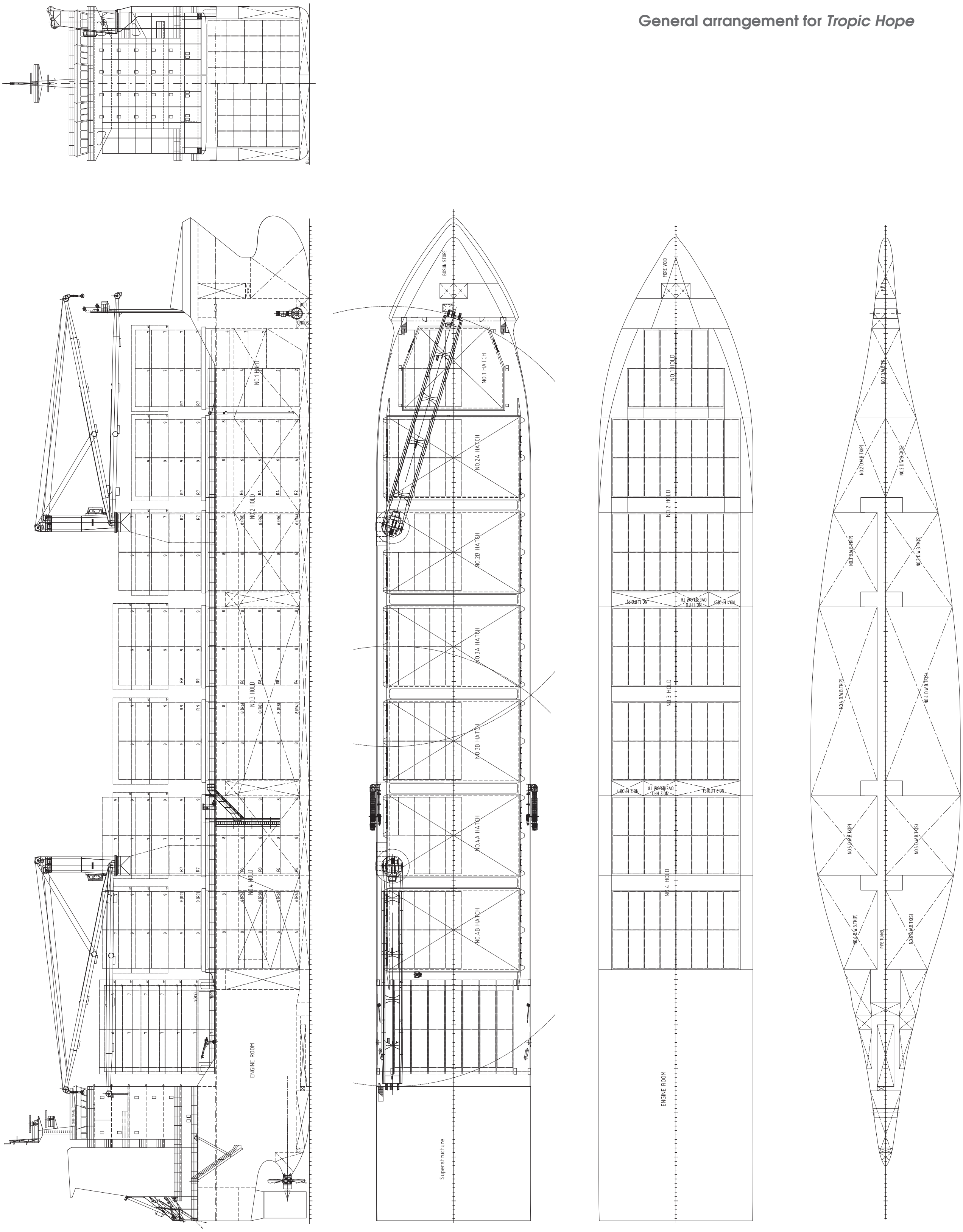
Critically important too is the meeting of Tier III NOx levels, given that *Tropic Hope* operates within both US Emission Control Areas: the North American and the US Caribbean Sea ECAs. In order to remain compliant, the vessel has a high-pressure selective catalytic reduction (SCR) system installed, bringing emissions within acceptable levels. Operating in waters under the jurisdiction of the US Coast Guard also mandates the installation of a USCG-approved ballast water treatment system, represented by a Headway OceanGuard system.

Hot or cold

A look at the vessel’s classification, provided by Bureau Veritas, further illuminates aspects of *Tropic Hope*’s design. For instance, in contrast with the features described above that lend themselves to operation in the Caribbean, *Tropic Hope* has been awarded ‘Ice Class IC’ notation. Although at the lower end of the ice class scale (the vessel does not have icebreaking capacity) the notation nonetheless responds to conditions at the northernmost port on the vessel’s route: Halifax in Nova Scotia, Canada. One significant feature that contributes to the achievement of this notation is the vessel’s double-skin hull, providing extra strength in ice-infested waters.

In sum, *Tropic Hope* is a well-designed vessel with regard to its operational profile. Whilst it may lack the glamour of a ‘smart ship’ replete with complex systems and technology, the pragmatic vessel is nonetheless innovative in meeting its owner’s needs, and clearly reflects the skill of ‘everyday’ naval architecture. *NA*

Tropic Hope is included in the Royal Institution of Naval Architects’ publication Significant Ships of 2018, showcasing the most innovative vessels delivered last year including Almi Atlas, Karios and CMA CGM Antoine de Saint Exupery.



General arrangement for *Tropic Hope*

Taking expedition cruising into uncharted waters

The first in Hurtigruten's new hybrid-powered explorer class, MS *Roald Amundsen*, is finally poised for delivery

The northern coast of Norway was once so busy and dependent upon marine traffic that it was known as the country's 'highway number one'. Many communities were not even linked by road and depended upon the ferry services offered by Hurtigruten (which translates as 'fast route'), a company founded in 1893 by government contract to improve communications between Trondheim and Hammerfest, with various calling points in between.

By the 1980's, improvements in road infrastructure and air services turned Hurtigruten's focus towards tourist services, in particular providing expeditions for the more adventurous cruise goer. "We are polar pioneers, pushing the boundaries," Hurtigruten CEO Daniel Skjeldam proudly proclaims. "We grew up with all the great Norwegian explorers such as *Roald Amundsen* and *Fridtjof Nansen*. We bring you closer to places that others can't go. We are the real thing. We're about authenticity."

While the hyperbole might be a little excessive, Hurtigruten does have a claim to being the biggest exploration cruise company in the world, travelling to 30 countries and 250 destinations, including tours to Antarctica. Once considered a niche subsector of the cruise industry, expeditions have surged in popularity in recent years, thanks to a combination of environmental, commercial and cultural factors.

Roald Amundsen will finally commence service in May

From offshore to expeditions

Much as the thawing of ice in the polar regions has inevitably led to commercial operators seeking to use it to their gain through the opening up of previously unnavigable sea routes, so too have cruise operators sought to capitalise upon the allure of those regions to tourists. But one of the more interesting consequences has been the opportunities it has presented to northern European shipyards, faced with uncertain futures following the slump in demand for offshore vessels, that have found their expertise in demand for constructing the smaller, more robust, polar-capable vessels suitable for expedition cruises.

Nowhere has this been more apparent than Norway's north-west coast. In 2016, Fincantieri subsidiary Vard secured a booking for four expedition ships from French operator Ponant from its Søviknes yard (the hulls being constructed at a sister plant in Romania) between 2018 and 2020, which was consolidated by orders for two sister ships and an LNG-propelled cruise icebreaker, even before it delivered the first ship, *Le Lapérouse*, in June last year. Elsewhere, American operator Lindblad Expeditions turned to Ulstein in ordering the *National Geographic Endurance* in 2017, with delivery set for 2020 from Ulstein's Ulsteinvik facility.

Meanwhile in 2016 Hurtigrutenentered into an agreement with Kleven Maritime for the construction of two new Explorer Class vessels, with the option for two more, at the Kleven Verft shipyard in Ulsteinvik. The following year, with Kleven on the brink of bankruptcy, Hurtigruten led a consortium which took a 40% stake in the yard, before becoming full owners in 2018.

MS *Roald Amundsen*

The lead vessel in Hurtigruten's new explorer class, MS *Roald Amundsen*, is currently undergoing completion at Kleven, alongside its sister ship MS *Fridtjof Nansen*. Although originally scheduled for delivery in July 2018, production delays mean it will now embark on its inaugural voyage, from Lisbon to the Atlantic islands, in May this year. It will follow that tour by recreating its pioneering namesake's journey through the Northwest Passage. *Fridtjof Nansen* will join it in service from Q3 this year, while an as-yet-unnamed sister is due for delivery in 2021.

The explorer vessels are intended to represent the cutting edge of sustainable marine technology and boast the capability to take passengers into remote and secluded areas that would be impregnable to larger ships. Designed by Rolls-Royce and Norwegian yacht designer Espen Øino, the vessels have a length of 140m, width of 23m and will be capable of carrying up to 530 passengers (265 cabins, with crew bringing the total capacity to 681 persons).

In particular, the vessels feature a "revolutionary" hybrid-powered fully electric propulsion system, powered by both fuel oil and batteries and capable of running almost silently. The propulsion system includes two Azipull thrusters, powered by a permanent magnet (PM) motor, plus two tunnel thrusters.

Uniquely for cruise ships, the main power for *Roald Amundsen* and its sisters will be provided by 4 x Rolls-Royce Bergen B33:45 medium-speed engines. Originally launched in 2014, the B33:45 is said to offer 20% increased power compared to its predecessor, delivering the same output with fewer cylinders.

The hybrid power system consists of 2 x 685kWh (1,750kW output each) batteries capable of providing full propulsion power for periods of 15-30 minutes. Significant additional storage capacity has been built into the engine room design with a view to making more extensive use of battery power in the future as the technology improves.

The IMO NOx Tier III emissions limit will be maintained by a selective catalytic reduction system. Overall, the hull design and hybrid technology is reckoned to cut fuel consumption and CO_2 emissions by approximately 20%, amounting to some 3,000mt per annum. Other features include the use of Rolls-Royce's Unified Bridge concept. The vessel has a service speed of 15knots.

Sustainable tourism

Although engines for the explorer vessels will run on MGO, Hurtigruten's Skjeldam explains that the decision not to run on notionally greener fuels such as LNG or LPG was based on the current lack of bunkering infrastructure. "The way we construct them now is the most environmentally friendly way of operating ships in these waters."

Notably, in November 2018, Hurtigruten did announce a long-term strategy to power its vessels using fossil-free liquified biogas (LBG) produced from dead fish and other organic waste. By 2021, the company plans to operate at least six of its 17-strong fleet with a combination of LBG, batteries and LNG.

This commitment to sustainability saw Hurtigruten become the first cruise company to ban single use plastics in July 2018. "This was very much an internally driven project," says Skjeldam, noting that when he visited ships, the crew were conducting their own calculations on how much plastic could be saved across the entire fleet.

Education is seen as an important part of the Hurtigruten message. Guests are brought ashore to collect plastic on the beaches in order to give them an insight into the damage being wrought onboard the world's most sensitive areas.

The heart of the vessel onboard *Roald Amundsen* and its sisters will be an 'edutainment' science centre, where guests and crew meet to develop a deeper understanding of the areas the ship is exploring, getting hands on with the latest technology and equipment, using science stations, navigating underwater drones and listening to the sound of whales.

"We are putting a lot of effort into being a corporate partner with all the big institutes and universities for science projects," says Karin Strand, a field operations manager for Hurtiguruten, highlighting a recent voyage during that dropped off two scientists from the Norwegian Polar Institute researching sustainable krill fisheries in the Antarctic. "My personal dream is that one day we can publish research papers based on science onboard our ships. Like a floating university."

However, those with a preference for relaxation are well catered for, with various onboard expedition equipment for excursions such as kayaking and explorer boats for safe landing in remote areas. There is also a choice of three restaurants, Scandinvian designed interiors, hand-picked art from HM Queen Sonja's art foundation and a 17.5m LED screen at the centre of the ship, where lectures and transmissions from outside the ship will be broadcast live. *NA*

The year of the expedition

Kari Reinikainen rounds up some of the most significant cruise ships scheduled for delivery between now and December

2019 will be marked by the delivery of several expedition cruise ships, many of them prototypes. In all 26 cruise ship newbuildings are due to be delivered this year, according to data gathered by Shippax Info, the Sweden based cruise and ferry industry publication.

In the mainstream cruise sector, it has become common practice for owners to build a series of ships using the same design, sometimes sharing it with a number of brands in the group. In such a case, the interiors will be tailored to meet the needs of each brand in question, but technical areas, to give one example, will not be affected.

Greg Mortimer. Photo: Sunstone Ships

This trend means many large ships that enter service (including several due this year), while representing significant additions to the fleets of their respective owners and operators, are not necessarily equally significant in any technical sense.

The rapidly growing expedition cruise market is much smaller in scale than the mainstream business, as are the ships, and typically only one or two are built to a single design. Furthermore, operations in often sensitive areas set their own requirements to these ships (see p.30-31 for article on Hurtigruten's *Roald Amundsen*).

Against this background, the still relatively small expedition cruise sector emerges as a dynamic part of the business when it comes to technical innovation.

Greg Mortimer

Under construction at China Merchant Heavy Industries shipyard in China for Sunstone Ships in the US, the 7,400 gross ton and 160 passenger capacity *Greg Mortimer* (named after the celebrated Australian mountaineer) has the distinction of being the first cruise liner to be built in China for a western owner.

The 104m vessel is designed by the Ulstein group in Norway, which has produced a portfolio of expedition cruise ships, many featuring the inverted X-Bow that it first introduced more than a decade ago. Makinen, the Finnish turn-key contractor, is responsible for the fitting out of the passenger and crew areas.

SunStone has chartered the ship on a long term contract for Aurora Expeditions in Australia. The Miami based company has contracted another four ships of the same type that it calls the Infinity class, which it also plans to charter out.

Costa Smeralda

The second in a series of LNG powered newbuildings for four brands of Carnival Corporation, *Costa Smeralda* will be the joining the Costa Crociere line.

The first, *AIDAnova*, was delivered by Meyer Werft in Germany late last year, while *Costa Smeralda* will come from Meyer Turku. Its predecessor company, STX Finland Oy, also built the dual fuel cruise ferry *Viking Grace* in 2013, the world's first major passenger ship to run on LNG, and feature a rotor sail.

At roughly 184,000gt, and with capacity for up to 6,600 passengers, *Costa Smeralda* and its sisters are the largest units built so far for the 100-vessel strong Carnival fleet.

Although not a prototype, *Costa Smeralda* is indicative of the growing use of LNG as fuel in shipping. It is also the first ship of Costa Crociere has built outside Italy since *Costa Atlantica* and *Costa Mediterranea* which both came from Finland at the turn of the Millennium.

Crystal Endeavor

The 19,800gt *Crystal Endeavor* will be the first deep sea newbuilding from MV-Werften, the German shipbuilder in the Genting Hong Kong group, which has built a number of high-end river cruise ships so far.

Costa Smeralda. Photo: Costa Crociere

Crystal Endeavor. Photo: Crystal Cruises

Spirit of Discovery. Photo: Saga Cruises

Crystal Cruises unveiled plans to build expedition cruise yachts soon after its acquisition by Genting in 2015. However, the design underwent several changes over time: the original, rather rakish appearance giving way to more businesslike lines. The ship will carry 200 passengers in high quality accommodations and is built to the IACS Polar ice class PC6 standard to allow it to operate in conditions that few purpose built cruise vessels are currently able to.

In all, three Endeavor class ships are on order at the German yard for Los Angeles based Crystal Cruises.

Spirit of Discovery

Spirit of Discovery is the first of two 58,250 gross ton newbuildings for Saga Cruises in the UK from Meyer Werft. It is also one of the few prototypes due for delivery this year outside the expedition cruise segment.

Designed to accommodate 999 passengers, *Spirit of Discovery* will feature a space ratio of 58, a rather high figure that highlights its aim to target the upper end of the market. It is the first newbuilding for Saga Cruises since it started operating cruises in 1997 and with its sister vessel next year, will allow Saga Cruises to sell two older ships that built in the early 1980s. Typically, high-end cruise ships – outside the expedition segment – now tend to measure roughly 50,000 to 65,000gt. A quarter of a century ago, many contemporary market newbuildings were of this size.

Although the aim of operators is to provide an intimate, low density environment to their passengers, they also need to be able to provide a range of facilities and a feeling of space that is easier to create on larger ships.

Seakeeping qualities, albeit not just a function of size, also support this approach if itineraries are to include long ocean voyages, as Saga Cruises is doing.

Scenic Eclipse

When the contents of the IMO's Polar Code became known a few years ago, the Australia based Scenic group was one of the first companies to sign a contract for a passenger vessel specifically designed to comply with the new rules.

The order for the 17,085gt *Scenic Eclipse*, as the ship would be called, was placed with the Uljanik shipyard in Croatia, which soon ran into difficulties that have severely delayed the delivery of the 228 passenger capacity vessel.

Scenic Eclipse will feature high ice class, utilising stabilisers that will be 50% larger than those traditionally used on cruise ships, eliminating movement when the ship is not moving. Helicopters and mini submarines will be carried on board the large expedition yacht. A second ship, to be called *Scenic Eclipse II*, is due from the same builders next year.

Azora

The US-based Ritz Carlton Hotel Company, part of the Marriott group, will become the first major hotel operator to enter the cruise industry when it takes delivery of the 26,500 gross ton *Azora* later this year.

Azora will be the first major cruise ship from Hijos de Barreras shipyard in Spain, better known as a builder of ferries. It will operate under the Ritz Carlton Yacht Collection brand name and carry just 298 passengers, placing it at the very top end of the market in terms of space ratio, which will be 88.

Only a few cruise yachts that feature a marina have been built since Kai Levander, then head of R&D at Wärtsilä in Finland, introduced the concept in the early 1980s. Levander's concept soon materialised in the two Finnish-built Sea Goddess ships of 4,200gt and 120 passenger capacity, but Ritz Carlton is now increasing the scale of the concept so

Scenic Eclipse. Photo: Scenic

that it resembles the expedition yachts of companies like Scenic or Crystal Cruises. However, Ritz Carlton's itineraries do not include high latitudes and ice conditions.

The Marriot group has indicated that it wants to build more larger cruise yachts, while retaining its cruise offering as a niche product.

Azora. Photo Hijos de Barreras

New builders, designs and owners

Until now, the French expedition cruise specialist Ponant has been one of the very few owners to take deliveries of newbuildings of this type – it will receive two more in 2019 – but this year the picture will be much more colourful.

The same goes for shipyards: in addition to China Merchants, a Chilean yard, one in Vietnam and several more in Europe have expedition cruise ships on order. The leading builders of mainstream cruise vessels all have sizeable order books and the smaller expedition ships do not necessarily fit well in the production flow of these yards, which has created an opening for newcomers to the sector.

Despite indications that the global economy could be heading towards a weak cycle, ordering of cruise ship newbuildings has not ended. Since the turn of the year, Norwegian Cruise Line Holdings placed orders for a total of three ships for two of its brands with Fincantieri.

As major newbuildings continue to enter service, it seems inevitable that several conceptually obsolete ships that do not feature many balcony cabins, for example, will be retired in the near future. *NA*

Are stern tubes necessary in modern shipbuilding?

Recent research presented by Thordon Bearings makes the case for seawater-based lubrication doing the same job just as effectively

Thordon Bearings has questioned the need for a stern tube in modern propeller systems, suggesting that shipbuilding and maintenance costs, complexity and time could be reduced by simply eliminating the cylindrical component through which the shaft passes to connect with the propeller.

In their paper *Eliminating the Sterntube in New Deepsea Ship Construction*, presented during October's SNAME* Maritime Convention 2018, Thordon Bearings' founder George (Sandy) Thomson (FSNAME) and Director of Engineering, Kenneth Ogle (FIMarEST), state that if the stern tube is removed, the surrounding seawater effectively becomes an "irregular shaped stern tube".

The potential obsolescence of this maintenance-heavy component is possible largely due to the advancements made in modern seawater-lubricated propeller shaft bearing and seal technology.

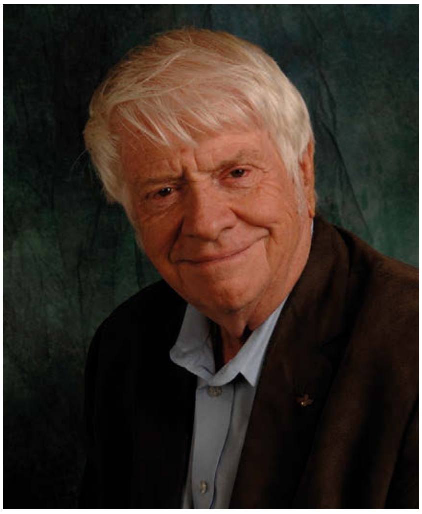
Typically, a shaft is inserted forward into the vessel through the aft bossing and into the stern tube. However, the section of the shaft inside the stern tube is notoriously difficult to position, align correctly and protect, often resulting in excessive wear and tear, corrosion problems and bearing and seal damage.

By removing the cylindrical stern tube, not only would it be possible to more efficiently align the shaft, it would make the shaft installation process easier, more controllable and faster for the shipyard, with added safety benefits, claim the authors.

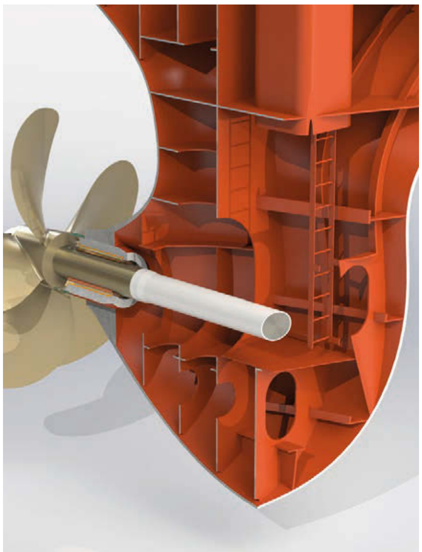
Without the cylindrical stern tube, polymer bearings with or without bronze carriers would be integrated into the vessel's steelwork after being cooled in liquid nitrogen and shrink-fitted into the bores in a way not dissimilar to a stern tube installation. Bearings would be locked from rotation with a fixed bronze key at the 12 o'clock position.

There is an alternate option using carriers chocked into the vessel steelwork. Here, bronze or phenolic bearing carriers would be accurately positioned within the stern castings and secured in place with chocking resin. This method simplifies the positioning process and eliminates the need for boring of the bearing castings. The build yard would make the decision as to which option best suits them.

The authors claim the benefits of building ships without a stern tube are commercially advantageous for shipowners. For instance, a typical bulk carrier with a 650mm shaft diameter and oil-filled stern tube would incur annual operational expenses of about US$31,244. This is based on the cost of environmentally acceptable lubricants (US$5,500), shaft seal maintenance (US$7,333), lubricant system maintenance (US$3,827), and emergency aft seal repairs (US$14,583).



Sandy Thompson, founder of Thorndon Bearings



Looking aft from inside stern tube space

The annual cost of operating the same ship without a stern tube and with a water-lubricated bearing system would be a negligible US$2,267, a reduction of almost US$29,000.

For survey purposes, with the shaft passing through a larger space, open and easy access is available to Class surveyors to inspect the shaft coating through a trunk from deck level.

Thomson adds: "Sometimes convention and history trump common sense, and we keep doing things the way we always have. For vessels with oil lubricated shafts a stern tube is an absolute necessity. When the owner chooses water it's not. The stern tube adds no essential structural strength, makes shafts hard to insert when slinging on the coating, is risky, and makes the job of the surveyor more difficult.

"Imagine how easy it would be for an inspector to descend through a trunk into a space where he can survey the shaft coating and liners with ease, check bearing wear-down and look for corrosion. It's a no-brainer and it saves cost for the yard and owner. Nothing is lost; everyone gains. Eventually, most propeller shafts will run in water, not oil. Why not now?"

'Eliminating the Sterntube in New Deepsea Ship Construction' was presented at the Society of Naval Architects and Marine Engineers' Maritime Convention in Providence, Rhode Island, on 24 October 2018. *NA*

Target markets inspire cruise ship design

YSA Design speaks to *The Naval Architect* about how changing tastes and sustainability are influencing the aesthetics of cruise ship interiors

While for many naval architects, the finer points of aesthetics can seem far removed from the structural design process, when it comes to cruise ship design an optimised hull form is not a selling point. The cruise ship operator's success is less contingent upon the speed and efficiency of passage than ensuring their guests' experience is 'special' enough to inspire future bookings.

For Norwegian ship interior and exterior architects YSA Design it's a process that typically begins when they are consulted shortly before the cruise operator signs a contract with the shipbuilder, according to Trond Sigurdsen, the company's chairman. Indeed, one of the biggest challenges is becoming involved early enough to ensure the technical specifications for the accommodation and public areas have been given adequate forethought in the naval architect's design.

He explains: "Good investment in the planning saves money and and improves the quality of the project, but not enough owners take that option. With many projects I've been involved with I've been looking at the spec the hour before they sign [with the shipyard] and there can be a whole list of problems that, if they don't get them resolved before signing, will mean a lot of substantial extras. So it pays to get everybody involved and ensures the end result is more predictable."

Recent YSA Design projects include the chocolate atelier onboard the *MSC Meraviglia*

Demographic deliberations

For the interior designer, the primary point of contact for any new project is the operator's marketing department to ascertain what the target clientele is and what research has been conducted into these potential guests. "The most important thing for us is what they're trying to convey," says Sigurdsen. "When we worked on the *Koningsdam* and its two sister ships for Holland America Line (HAL) they wanted to go for a younger demographic, which meant a serious shift in design for the whole ship."

YSA has a wide range of clients and with that comes the need for a variety of different design solutions, ranging from classical to minimalist, and requires a team including architects, designers and textiles specialists. Each cruise line has its own distinctive ambience and identity which is key in persuading passengers to repeat the experience time and again, yet at the same time wants to attract new guests.

Moreover, the cliched image of cruise passengers as blue-rinsed old ladies belongs to an earlier era. Figures published by the Cruise Lines International Association reveal that between 2002 and 2015 the average age of a cruise passenger dropped from 56 to 46. Some operators, such as MSC, pride themselves on catering for different groups on the same ship, so that families, older passengers and those looking for a more cultural experience all enjoy a cruise that's customised to their particular predilections.

Ethical questions

Passenger demands now increasingly extend beyond aesthetic considerations into ethical ones and questions of sustainability, particularly as regulations such as the Hong Kong Convention will require the demonstration of environmental responsibility in the materials selection and full inventorying of what has been used. "Teak decks, for example, are gone except on a few luxury cruise ships," observes Sigurdsen, who stresses that a beautiful ship is also an efficient ship and not mere aesthetics. One respect in which this has impacted upon YSA Design's creative ideas has been the integration of solar panels that can serve as auxiliary power sources.

Much of that green pressure comes from the younger generation, whose own preferences often lean towards the 'realer', less luxurious experiences offered by expedition ships. YSA Design has itself been consulted by shipyards in the tendering process for a number of such vessels and has several projects in various stages of development.

Other recent and ongoing projects include work for Disney Cruise Line and a steady stream of work from MSC, for which it made a significant contribution on the 2017-delivered *MSC Seaside* (see *The Naval Architect*, February 2018). "And of course we're really happy to be working on the Venetian restaurant for the *Costa Venezia*, that's a very special concept," says Sigurdsen.

One particular area in which YSA Design has distinguished itself is in the integration of art into its designs, epitomised by HAL's *Nieuw Statendam*. The 2,666-guest capacity ship, delivered in December 2018, has been furnished with more than 2,500 curated works from new and emerging artists. "To work with artists has been really refreshing because you have to give over control to somebody else," says Sigurdsen. "It generates changes in the design to truly appreciate the impact of the artist." *NA*

Human Factors and cabin design

Niels de Groot gives an insight into the ergonomic and aesthetic considerations which influence modern accommodation design

The aim of Human Factors (Ergonomics) is to optimise the fit between the human operator and the working environment, in order to achieve efficient and safe operation in a healthy and comfortable way. Applying Human Factors to ship design has several interesting goals, such as optimised ship handling, minimal crew size and improved field-of-vision. Attractive and ergonomically well-designed ships are also a joy to work on: important in keeping crew motivated and happy.

Although Human Factors Engineering is well embedded in the worlds of process control and traffic management, most naval architects focus on the technical aspects of ships, rather than on the people working on board. This is a bit surprising, given the roadmap to autonomous shipping will require radical reductions in crew size. Doing the same set of tasks with a much smaller crew means that a lot of effort must be put into the changing role of the human operator on board.

In a maritime context, the working environment is often a living environment as well. On most seagoing vessels people work, sleep, eat and recreate, usually for a considerable period of time. Each of these functions results in specific requirements for the vessel's design. This can be challenging, since most functions are carried out at the same time, often 24/7 and in a shared space.

The main purpose of crew cabins on a ship is to provide a comfortable and quiet place to sleep. Single-person cabins, both thermally and acoustically insulated, with good quality mattresses are now standard in shipbuilding. Apparently, this basic requirement is covered, so what is the next step? From a Human Factors & Ergonomics point of view, it is possible to bring the cabin design to the next level by applying psychological principles about human behaviour and wellbeing.

The 3D image above shows a mid-sized crew cabin (15m^2), in which 24 subtle innovations were incorporated, based on Human Factors design principles. Together, they create a practical, nice and cosy cabin. Only standard maritime components and

Design 'tricks' help create the impression of a comfortable and spacious cabin

Wheel Mark approved materials were applied. The design is compliant with regulations and can be built without any additional costs. Below is a selection of 5 interesting design hints:

Perceived cabin size: Arrange the most commonly used sitting furniture like settee and bed, in a way the user can overview a large part of the room space, specifically at ceiling level, to maximize the 'perceived cabin size'.

Colours and materials: Use a balanced mix of coloured surfaces, grey tones and textures to make the room visually more appealing. Two colours, two grey tones and one or two wood patterns will usually do the trick. Have a look at the effect of the blocked bed cover: the pattern adds a bit of variation to the plain colours of the other furniture elements, making it visually more interesting. Avoid using hard materials only, like vinyl flooring and fake leather upholstery. Carpet and textile fabrics feel more comfortable and have better acoustic characteristics too.

Sensible decoration: The wall picture of the lighthouse landscape brings a 'touch of home' into the cabin – in this case for a Dutch crew. Using exterior sceneries for decoration can also contribute to the perceived cabin size. Note that the picture scenery (horizon) continues into the real world window next to it.

Daylight and artificial light: Lighting should be functional, but also interesting. Avoid a flat and even light level in the entire cabin. A combination of direct, indirect and spot lighting gives the best results. In the picture this is accomplished by using a ceiling light, wall mounted light, and two reading lights. Use multiple windows whenever possible, preferably on different walls. This results in a better and more natural light distribution.

Shower curtain: Shower curtains are commonly used in wet units to prevent everything getting wet when taking a shower. Because of the upward airflow while showering, the plastic curtains tend to fold inwards and annoyingly 'stick' to the users' body. A better solution is to use a glass door panel or a fixed separation wall panel.

Interested in the complete list of ergonomic design improvements, or in more do's and don't concerning Human Factors of ship's design? Please take a look on **www.maritime-ergonomics.com**.

About the author

Niels de Groot is a Certified European Ergonomist and Senior Human Factors Consultant at ErgoS Human Factors Engineering. He will be contributing further on the subject of maritime ergonomics to *The Naval Architect* later this year. *NA*

Validation of wind loads on a slender vessel using CFD

A joint project between Damen and CFD software supplier Numeca has shown favourable results compared to traditional model testing

J. W. Vogt, Damen Shipyards, Singapore
M. Bovio, J. de Baar & A. Betge, Damen Shipyards, Netherlands
B. Mallol, Numeca International, Belgium

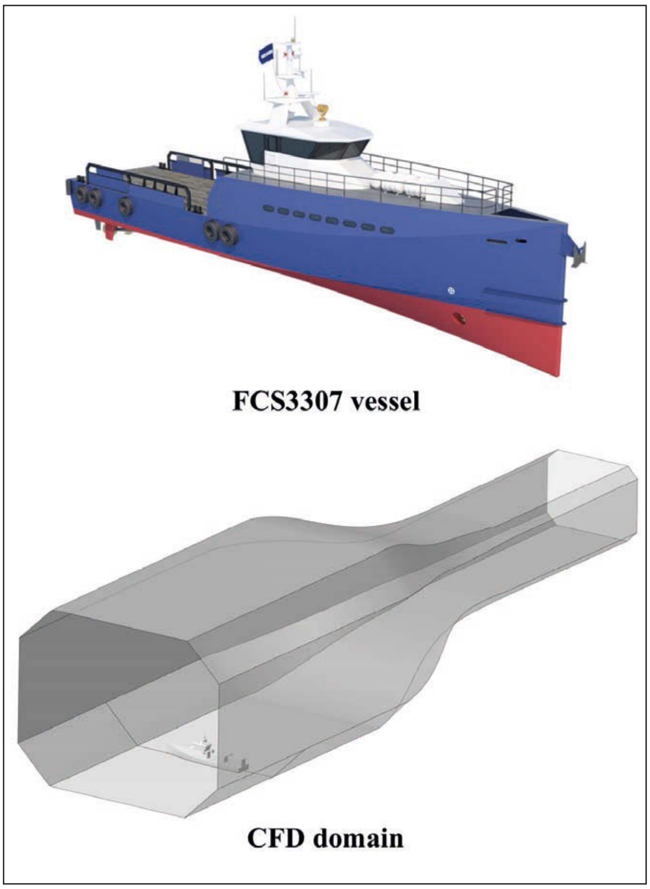


Fig 1. Vessel and CFD domain

The IMO regulation 749.18, 'Severe wind and rolling criterion (weather criterion)', ensures a vessel has sufficient transversal stability to resist over-rolling in severe side winds. But for some long, slender vessels it can be difficult to comply with the empirical requirements of this regulation. Therefore, the regulation allows for compliance to be demonstrated by means of model scale experimental measurements – from both a towing tank and wind tunnel campaign. In doing so, the hydrodynamic and aerodynamic lever arms, under side wind conditions, can be determined for various heeling angles and assessed as to whether the vessel is compliant and able to operate unrestricted.

By necessity, the regulation is conservative so that it can be broadly applicable to a multitude of vessels. However, slender vessels may have difficulties satisfying its empirical requirements, requiring expensive experimentation to demonstrate compliance with the regulation. In order to reduce the costs, shipbuilder Damen, in partnership with its CFD code supplier Numeca International, has developed a CFD methodology that can be used in lieu of experimentation and demonstrate compliance to the satisfaction of classification societies.

The CFD methodology described here is focused on the prediction of the aerodynamic forces only. As the motivation for using CFD is primarily cost and time related, it is imperative that the methodology be both sufficiently accurate but also with as low as possible computational cost and total turnaround time. The methodology reflects these aims.

There is a shortage of documented methods for the accurate numerical modelling of wind loads over maritime vessels. But a small number of researchers have simulated flow over wind exposed hulls and superstructures of various forms, with differing approaches and levels of fidelity. Validation for these cases (comparing either velocity probe or force data) is generally good in qualitative terms, although perhaps insufficient quantitatively (Polsky, 2002; Wnęk and Guedes Soares, 2015; He, et al. 2016).

A thoroughly and successfully validated investigation was undertaken by Forrest and Owen (2010), who performed full-scale Detached-Eddy Simulations (DES) of the flow field over a navy frigate in order to predict the flow field encountered at the helicopter landing pad on the vessel's rear deck. The model was validated against model-scale experimental hot-probe velocity data. The scale difference between the simulation and experiment was disregarded as the scale effect was demonstrated to be minor. Using an unstructured mesh of 7.4×10^{6} cells, a relatively large normalised timestep Δt^* = 0.0188 (normalised by wind speed and vessel beam) and the k-ω SST turbulence model, good qualitative agreement was seen for the time-averaged flow field over the landing pad and in the Power Spectral Density (PSD) comparisons of velocity, at various points on the ship.

The present paper reports the results of a CFD validation campaign where a

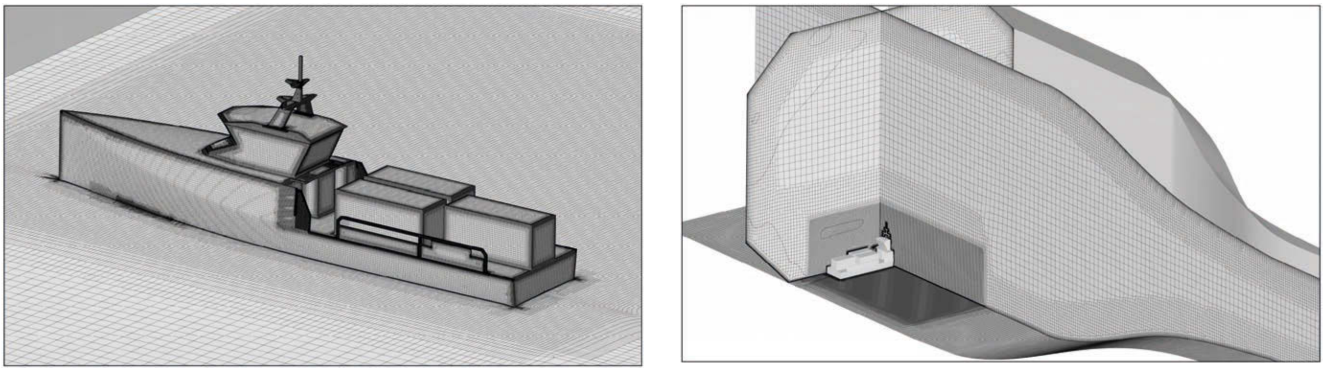


Fig 2. Numerical mesh, heading = 90°, heel = 0°

wind tunnel test of the Damen Fast Crew Support (FCS) 3307 vessel was numerically replicated (see Fig.1).

Experiment

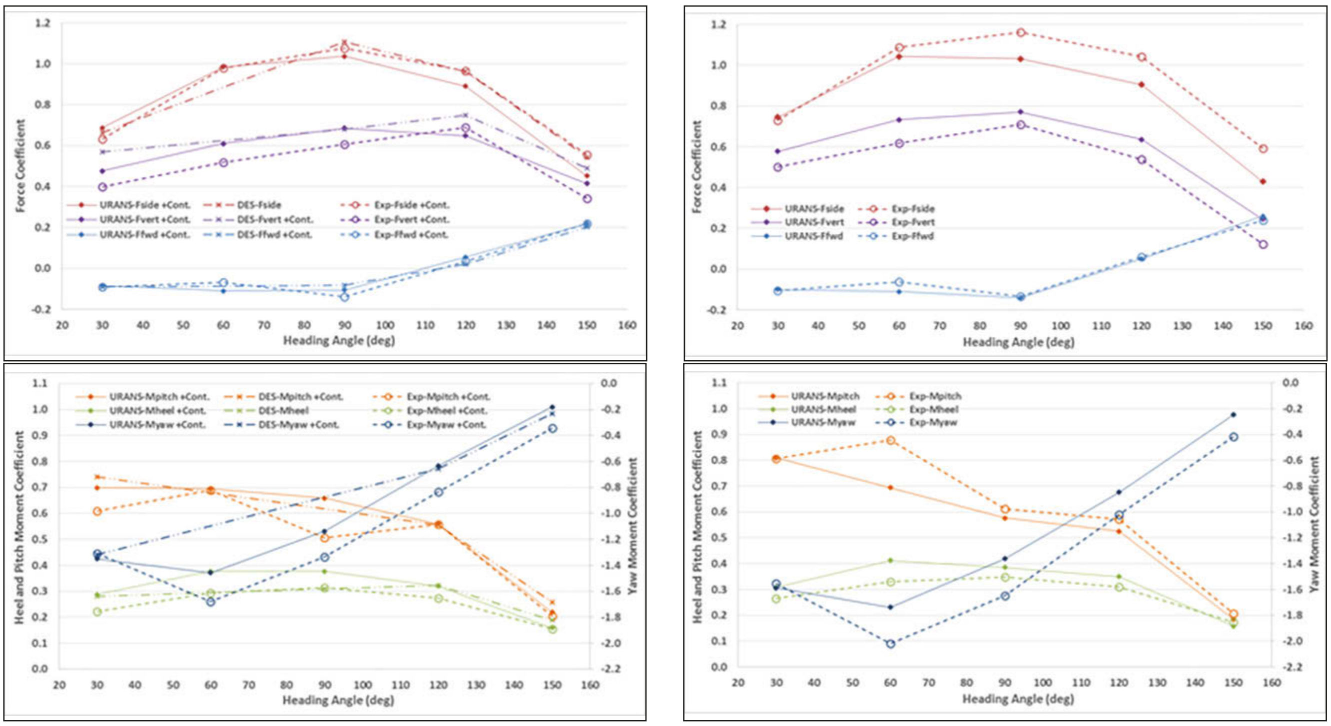
The experiment was undertaken at the University of Southampton wind tunnel using a 1:18 scale model of the 33m long FCS3307 vessel. The institute provided the 3D geometry of the testing facility, in order to allow a realistic reproduction of the environmental test conditions in the CFD model. Testing was conducted at various heading and heeling angles, and also with and without containers on the rear deck of the vessel, to take account of the different operating configurations of this unit. The model was kept at a constant longitudinal (zero) trim while maintaining the same displacement at different heeling angles. The model and sting were mounted in a small pool of water around the model (with the waterline flush with the floor of the tunnel), to avoid air recirculation under the model.

All tests were performed at a freestream velocity of approximately 7m/s, maintaining the flow above the critical Reynolds number (Re), (about 2.7×10^5, based on the vessel beam). The Re was further raised by the introduction of additional turbulence to the tunnel through screens. The boundary layer profile at the test section was measured (without the model installed) and this was used to calibrate the CFD model. The results, against which the CFD model was compared, were corrected for tare drag (less than 2% of the measurements, in all cases) but were not corrected for blockage effects, allowing for a like-for-like comparison with the CFD model.

Conceptual model and numerical mesh

The computational domain reproduced the test-section and downstream contraction of the University of Southampton wind tunnel. This arrangement allowed for the faithful reproduction of flow field and blockage conditions apparent in the

Fig 3. Model-scale force and moment coefficient results for URANS, DES and experiment, with (left) and without containers, zero heel



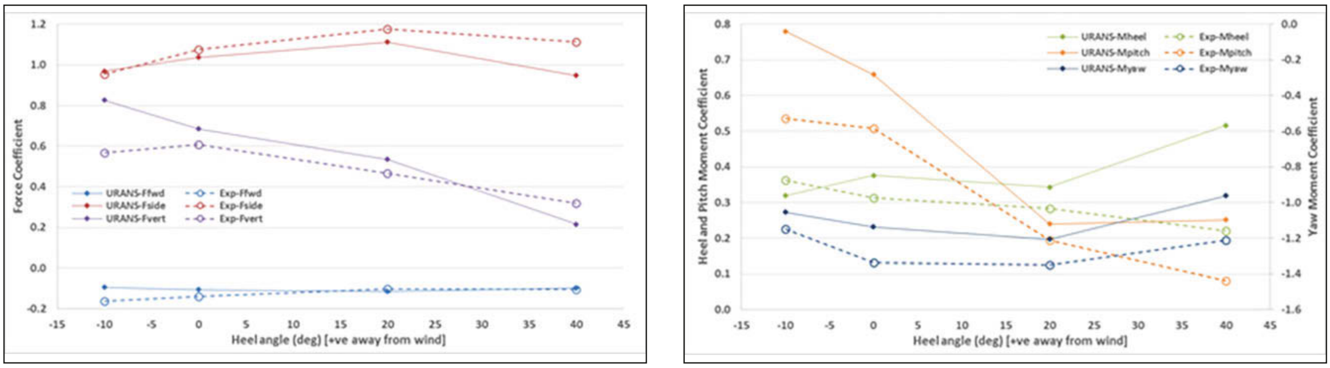


Fig 4. Model-scale force and moment results for URANS and experiment, at different heeling angles, with containers, heading = 90°

experiment. Turbulence screens upstream of the test section increased the turbulence and also straightened the flow after a 90° corner in the tunnel circuit.

Measurements taken in the empty tunnel showed a semi-developed and highly turbulent boundary layer. To correctly reproduce the boundary layer velocity profile, the numerical model required a distance approximately 3 m to the centre of the test section, employing a Turbulence Intensity (TI) of 10%. This value was determined through trial-and-error as the experimental TI was not recorded. To correctly characterise the profile, it was necessary to fully resolve the boundary layer on the floor of the tunnel, from the inlet to the installed model.

With a view to facilitating the quickest and simplest model preparation, the water pool in the wind tunnel was not included in the CFD model. Rather, the model was simply truncated at the solid tunnel floor with the submerged portion of the model disregarded. The resulting solid surfaces of the model do not form a sealed volume (with an opening at the tunnel floor), leading to a significant imbalance in the resultant vertical force acting the on model. This was accounted for in the CFD model by applying a vertical correction force acting at the centroid of the model-tunnel floor cross-section. The correcting force was defined as the ambient pressure in the domain, multiplied by the cross sectional area. This vertical force vector also provided corrections for pitch moment and heeling moment.

The numerical mesh was generated with Numeca's Hexpress Hybrid, a general purpose script-based automatic mesher that generates hex-dominant unstructured meshes about arbitrary and complex geometry. An initial mesh sensitivity study using a URANS solver, testing meshes between 8×10^6 and 182×10^6 cells, informed an initial mesh density that ultimately produced meshes between 10 to 13×10^6 cells, depending on the model arrangement.

The mesh concentrated spatial refinement on the model and wind tunnel surfaces. Two refinement boxes were used around the vessel and in its wake, to capture the flow details with greater fidelity. The wind tunnel floor had a fully resolved boundary layer mesh from the inlet to the model, with a y^+ of approximately 0.4. The viscous component of the forces acting on the model were expected to be extremely small, and with no smooth surface separation or opportunity for boundary layer development, there was no need for a detailed boundary layer mesh (see Fig. 2).

Numerical settings

The solver FINE/Marine v6.1, by Numeca, was used for all simulations. It utilises the finite-volume method for the solution of the incompressible Navier-Stokes equations. It is an unstructured, face-based, segregated solver and its fully unsteady solver utilises an implicit second-order accurate temporal discretisation scheme.

The mesh was prepared with the intention to compare the effectiveness of both the Unsteady Reynolds-Averaged Navier-Stokes (URANS) solver approach and the DES approach. DES has the advantage of being able to explicitly resolve the large scales of turbulence, which is particularly advantageous for large-scale separation off bluff bodies. The DES model switches between an explicit resolution of the larger turbulent scales or a turbulence model calculation, based on the local mesh cell size. If the cell is not small enough to capture the larger scales, the DES model will be inactive and effectively behaves as a URANS solver.

For the URANS solver, the convective terms were discretised using the AVLSMART scheme (Pržulj and Basara, 2001), which is based on the third order QUICK scheme. For the DES solver, the convective terms were discretised using a blended scheme between first order upwinding and central-differencing, with a 5% weighting to upwinding. The turbulence model used was the Explicit Algebraic Stress Model (EASM), which is based on the k-ω SST model but better accounts for the rotational component of turbulent flows.

A constant velocity V = 6.98 m/s was applied at the inlet. With development of the boundary layer, the freestream velocity reaches 7m/s at the ship model. The turbulent quantities at the inlet were set to $k = 2.1565 \times 10^{-7}$ m^2/s^2 and $\omega = 14.0$ /s (= V_{ref}/L_{ref}), which corresponds to a TI = 10%. The tunnel outlet was set to a constant pressure outlet.

Timestep sensitivity studies were undertaken for both URANS and DES approaches. The present mesh was temporally independent with a timestep of Δt_{URANS} = 0.1 s for URANS. For the DES solver, no change in the temporally-averaged forces and moments were observed with a timestep smaller than Δt_{DES} = 0.01 s. This was considered quasi-temporal independence for the DES solver. When normalised in the same way as Forrest and Owen (2010), $\Delta t_{DES}^* = 3.67\times10^{-3}$, which is only one-fifth of the normalised timestep employed in that study. The URANS cases solved 10 iterations per timestep, while the DES cases solved 15 iterations per timestep.

In order to approach the solution as quickly as possible and reduce the overall solution time, an initial steady-state RANS simulation was conducted for just 100 iterations. This short simulation was sufficient to develop the flow field to a point such that it was a good starting point for both the DES and URANS models. This saved significant flow development time for both solution strategies.

The URANS cases, initialised from the steady state run, computed between 700 and 1,500 timesteps, depending on the model arrangement. The simulation was run until the forces, moments and residuals had settled to a constant value. The DES cases were first computed for 150 timesteps to overcome the transient phase and achieve quasi-steadiness. A data averaging simulation was then initialised from this run and computed for about 1000 more timesteps (180 flow times across the model beam).

Table 1. Simulated cases

Heading (°)	Heel (°)				
	-10	0		20	40
	w. cont.	w. cont.	w/o. cont.	w. cont.	w. cont.
30		URANS, DES	URANS		
60		URANS	URANS		
90	URANS	URANS, DES	URANS	URANS	URANS
120		URANS, DES	URANS		
150			URANS		

Table 1 shows the conducted simulations, indicating the heading and heel angles and whether or not the containers on the deck were included. A heading angle of zero represents a bow into the wind condition, 90° is wind onto the portside. A positive heel angle represents the ship leaning away from the wind. The model including the containers increased the frontal area of the model (at heading of 90°) by 19%.

Results and discussion

The results for the zero-heel cases, alongside the experimental results, are shown in Fig. 3. They are presented in terms of the forward (to bow), side (to starboard) and vertical (upward) forces, and the pitching, heeling and yaw moments. Very good qualitative agreement is found, both with and without containers. The agreement at the 90° heading case (side-on to the wind) is the most favourable – the side force is predicted within 12% without containers and within 4% with containers. For all headings, the solved forces generally achieved a lower percentage error than did the moment results, but the discrepancy was very similar in absolute terms. The CFD model tended to be further from the experimental results at heading angles increasingly distant from 90°, in both directions. This may be due to the increasing non-alignment of the freestream mesh cells with the ship model and the resulting complex tetrahedral mesh that is imposed near the ship surface.

The DES results in Fig. 3 indicate that, in general, the DES solver is slightly superior to the URANS solver, in terms of the calculation of forces and moments. The side force prediction in particular is significantly improved with the DES solver. It produced a less accurate result for the vertical force and relatively unchanged or slightly better for the forward force and the three moments.

The results for the heeled case are shown in Fig 4. The qualitative agreement is again very good, however, the correlation generally deteriorates at heel angles increasingly distant from zero and, again, in both directions. With the current, limited mesh refinement, discretisation errors may be contributing to the errors seen on the more extreme cases.

The URANS solver was not able to capture the inherent highly turbulent nature of the flow field, which is demonstrated quantitatively in Fig. 5 and qualitatively in Fig. 6. The URANS solution shows no evidence of time-dependant turbulent eddies, whereas the DES solution shows significant turbulent behaviour and a very high level of mixing. Although there is some local variation in the forces acting on the vessel (see Fig. 5), the position of the centre of pressure varied very little, not exceeding $0.01L_{pp}$.

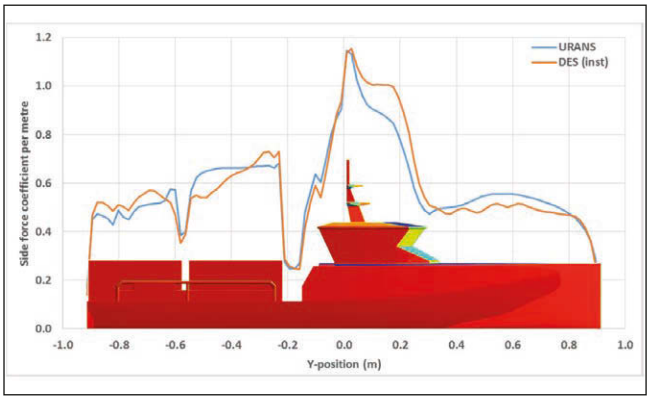


Fig 5. Side force distribution, heading 90°, heel 0°

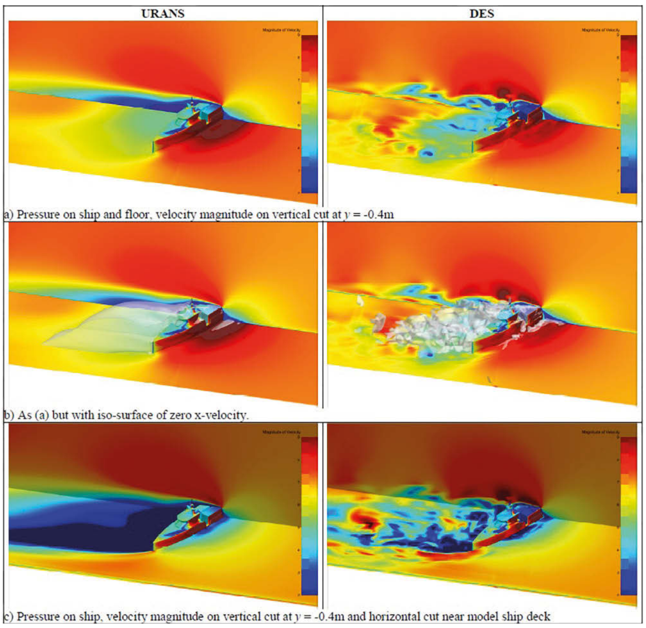


Fig 6. Qualitative comparison of flow field; heading 120°, heel 0°

Conclusions

The CFD model reproduced the validation wind tunnel experiment and tunnel apparatus and achieved good correlation for forces and moderately good correlation for moments at various heading and heeling angles. The DES methodology was favourable in terms of its ability to capture the flow features. It also achieved slightly better correlation with the experimental data.

The URANS solution, though unable to capture the temporal character of the flow, was able to predict the forces and the moments with good accuracy and was also slightly cheaper to run than the DES server. Given the highly turbulent nature of this bluff-body separation problem, prediction of full-scale loads should be quite reliable. *NA*

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Full-scale simulation for marine design: a review

Professor Milovan Peric, originator of Siemens' STAR-CCM+ software platform, has taken a fresh look at full-scale CFD simulation in a soon-to-be-published white paper

Computational fluid dynamics, or CFD, is a widely used tool in the marine industry, and can be reliably used to predict resistance, propeller thrust, cavitation pattern, added resistance in waves, wave-structure interaction, etc. Standard practice has been to perform simulations on a scaled model, equivalent to that used in towing tank testing. This 'virtual towing tank' approach has been well-validated by comparison with measurement data from scaled model tests. There is however a growing school of thought which asserts that CFD should be routinely used to simulate vessels at full scale. This removes any uncertainty introduced into results from empirical scaling factors and allows vessel performance to be predicted under realistic operating conditions. However, when it comes to applying CFD at full scale, there are still many reservations. Some of these concerns are based on the belief that at such high Reynolds numbers, wall boundary layers cannot be handled accurately enough in a simulation; other doubts exist because there is limited test data from full-scale measurements that can be used for validation.

Prof. Milovan Peric has a long history of using CFD in marine applications. He has recently taken a new look at the use of full-scale simulation and summarised his thoughts in a white paper, 'Full scale simulation for marine design', soon to be published by Siemens Digital Industry Software. Peric is confident that the accuracy of properly conducted CFD prediction at full scale is no worse than at model scale, and the reliability of the results is no worse than the reliability of extrapolation from model-scale experiment to full scale. In many cases, full-scale prediction is more accurate and reliable. The reasons for this confidence are based on his experience with Siemens' Simcenter STAR-CCM+ software.

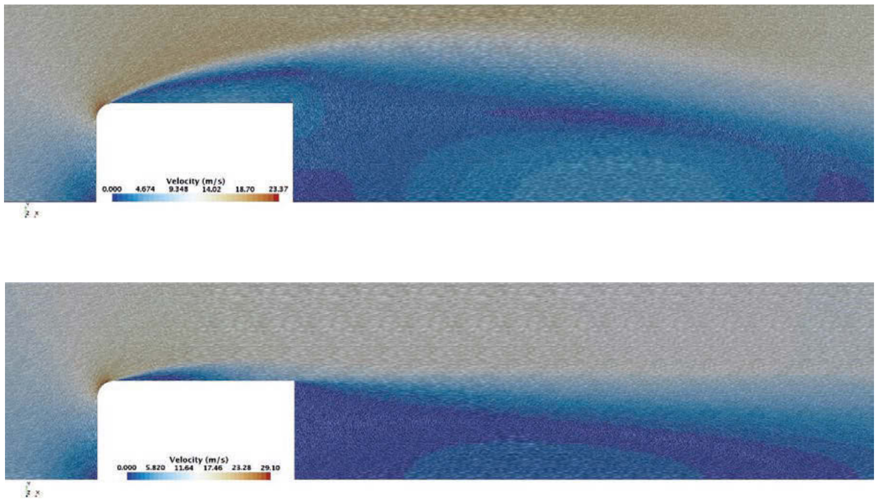


Figure 1: flow separation on a square cylinder with rounded corners: Reynolds number 500,000 (upper) and 5,000,000 (lower). The flow structure is significantly different at higher Reynolds number, equivalent to a full-scale model

A discussion of the validity of full-scale CFD must start with analysis of Reynolds number effects and computational mesh requirements, since these apply to every simulation. Peric has carried out a thorough analysis of each of these important aspects:

Reynolds number effects on flow features

It is well known that the transition from laminar to turbulent flow depends on Reynolds number, as does separation around a bluff body. In marine applications, experiments at model scale must enforce Froude number as well to ensure effects such as wave phenomena are correct. This means the Reynolds number for a model-scale test is much smaller than that at full scale, which can lead to incorrect predictions of flow pattern (as shown in Figure 1), and difficulties in scaling results. This inability to match both Froude and Reynolds numbers can be a significant problem for experimental results, especially when analysing a novel design where there is no previous experience with similar shapes, and standard scaling factors may not apply. On the other hand, CFD simulations can be performed at full scale as easily as at model scale, removing the need for scaling factors, and ensuring flow features are correctly predicted. With the growing need to examine novel designs such as energy saving devices (discussed below), analysis at full scale will provide more confidence in the results.

Wall boundary layers

The quality of CFD solutions depends strongly on the quality and resolution of the computational mesh. Of prime importance is resolving the boundary layer, for example along hull surfaces or propeller blades. A suitable mesh requires many prism layers near the wall, which when combined with a suitable turbulence model ensures correct modelling of the boundary layer flow. At full scale the Reynolds number is much higher than at model scale, and the boundary layer thickness is much smaller compared to ship length. Many people believe that CFD in full scale is therefore too costly because one needs extremely fine grids in order to obtain y+ values at the near-wall cell center in the range that is considered reliable based on model-scale studies. Peric argues that there is no need to refine the prism layer: instead, wall functions can be used which mean the grid only needs to resolve the logarithmic part of the boundary layer. An analysis of the ratios of y+ at full and model scale shows that at full scale, it is appropriate to place the same number of computational points in the boundary layer as at model scale. This means that full scale meshes are no more computationally expensive than model scale.

While the above discussion has shown that there are no physical or computational reasons to prevent full scale CFD simulations, Peric has also looked at specific examples where full scale simulation provides additional benefits over model scale:

Propulsion systems and cavitation

Experimental prediction of cavitation has a high level of uncertainty, due to both differences in scale and rotation of the propeller, and differences between test conditions and actual operating conditions. CFD simulation removes the problems with model scale rotation and resolution, and can easily account for the proper environmental conditions. Cavitation is predicted using a cavitation model, since we cannot afford to resolve each vapor bubble in the computational grid. This can introduce additional modelling errors into the system, but this is the only uncertainty, since at full scale simulation the the proper environmental conditions are accounted for, as well as the free surface deformation as the propeller rotates. Professor Peric cites recent investigations which have shown that cavitation in the tip vortex can also be well predicted in simulation, provided suitable local mesh refinement is applied.

Energy-saving and flow control devices

Energy-saving and flow-control devices are usually small parts relative to ship size. This makes testing at model-scale difficult, as the Reynolds number based on their characteristic length may become subcritical at model scale, while at full scale the boundary layer would become turbulent before separation and a much smaller recirculation zone would result. It is therefore difficult to analyse, and especially to optimise, energy saving devices and similar small parts using scaled-down models. Although experiments may be difficult to conduct at full scale, for CFD simulation the effort is nearly the same, irrespective of the size of flow domain. Indeed, problems with several designs not performing in full scale as expected based on model-scale experiments have been solved using full-scale simulations.

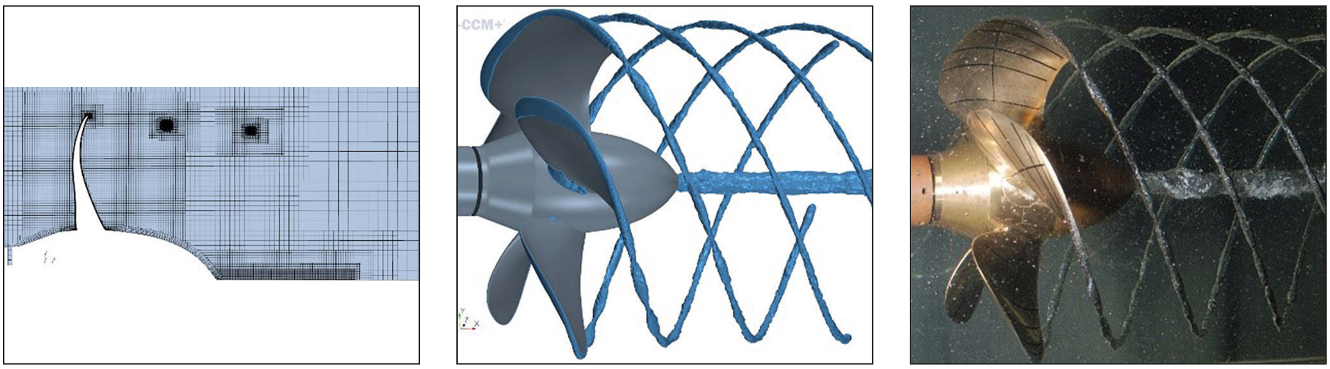
> "Experienced users in the maritime sector are already routinely and successfully applying CFD"

Validation data for full scale simulation

The amount of data obtained on full-scale marine structures is limited, and more data is desirable in order to raise confidence levels. For example, data such as ship speed as a function of propeller revolution and sea state is already routinely collected during sea trials: if this data was made publicly available it could be helpful for use in validation. In November 2016, Lloyd's Register organised a workshop at which more than 20 companies presented comparisons of simulation results with full-scale measurements for a medium-size ship. The workshop demonstrated if simulation is performed by capable engineers using state-of-the-art CFD tools, they can predict ship performance at full scale. The results which came closest to experimental data (less than 1% difference) were also obtained using Simcenter STAR-CCM+.

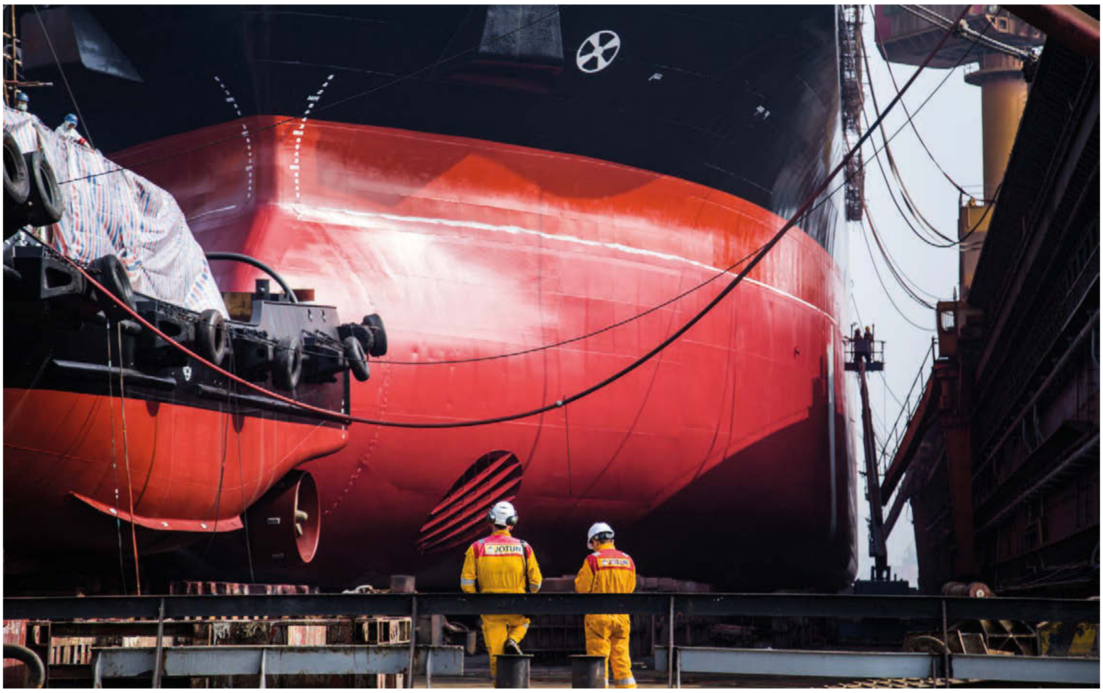
Peric concludes: "Many experienced users in the maritime sector are already routinely and successfully applying CFD simulations under full-scale conditions. For those who are still hesitating, it is time to start gathering experience since the trend is clear. Using CFD software such as Simcenter STAR-CCM+ makes it possible to meet the goal of conducting full-scale analysis of complete systems under realistic operating conditions by creating a digital twin of the real system." The full white paper will be published by Siemens later this month. *NA*

Figure 2: Computational grid used to simulate cavitating flow around a propeller. Local refinement ensures accurate capture of the tip vortex. Experimental image courtesy of SVA Potsdam



If the coating fits

Jotun's Hull Performance Solutions offering, underpinned by data collection, can deliver significant fuel savings – but the vessel must be right



Jotun established Hull Performance Solutions in 2011

It's not often that a paying customer is turned away in the world of business. However, the complexities and tight budgets found in maritime mean doing so is sometimes the best option, both for the customer and the company. A case in point is Jotun's Hull Performance Solutions (HPS) offering – according to Global Concept Director Stein Kjølberg, "I have never in my career said no to more customers than with HPS…I say there's no point investing that much more if you can get away without it."

Kjølberg's honesty may be refreshing, but he's also realistic. The Hull Performance Solutions concept is based upon the application of advanced antifouling products, the performance of which is then measured by meticulous data collection and analysis, with the aim of delivering up to 15% in propulsion efficiency and resulting in 8.5% fuel cost and GHG emissions savings. Only vessels with a suitable operational profile – usually those of significant size, on long, regular deep-sea routes, such as containerships – are likely to see a benefit that surpasses the initial investment required. Besides operational profile, some vessels may be too close to the end of their lifespan, or not able to do a full paint blast, based on the time between drydockings.

When assessing a vessel's suitability, Jotun looks at vessel speed, the average temperature of the seawater on the vessel's routes, and the number of days active through the year. AIS data is also leveraged to account for actual operation, since the newbuilding spec isn't always met in reality. This can be important in the case of seawater temperature, for instance, where if the spec cites 25°C, but trading is undertaken at 30°C, the antifouling will need to be different.

Less suitable vessels may still experience minor savings, but for Kjølberg, it is better to target vessels for which HPS is tailored. This is especially important given that Jotun include a high-performance guarantee, meaning the company will be liable to pay up to 60% back if HPS doesn't deliver on contracted promises. With 900 references to date, though, Jotun has evidently identified a sizeable market segment that responds well to the concept; there has been only one performance-related payback so far, which Jotun attributes to a failure to apply enough paint to the newbuild vessel following a spec change (although it paid out nonetheless).

Data collection

The foundation of HPS, as mentioned, is data collection. Vessels must first be equipped with (or utilise existing) sensors, including a Doppler log, torque meter, draft meter, and anemometer, which are integrated with the vessel's GPS and a data-logging unit. High-frequency data is then collected on an almost constant basis – every 15 seconds – and combined with traditional vessel noon reports through in-house data analysis at Jotun to "give a good assessment of performance," says Kjølberg. This performance regards fuel savings delivered by the antifouling as it cancels out speed loss, and the change in antifouling efficacy over time (and, by extension, the benefits delivered at drydock as the hull is re-coated).

"The high frequency data can tell you exactly what is happening, and the noon data is more like trends," Kjølberg advises. "The difference is between the accuracy – if you use high frequency data, you have plus/minus 0.3% points, whereas for noon data it can be anything from 4 to 5%." Some owners are unwilling to invest in sensor equipment to collect high-frequency data, he claims, saying they are happy with the insights provided by noon reports. However, charterers may see a differnet side, Kjølberg notes: "If the charterer can accept plus or minus 5%, that's fine, but owners can make their vessels a lot more attractive to them [using high-frequency data]."

With such a rich data set to draw from, owners can gain useful insights unrelated to the application of antifouling – something that Jotun encourages, as it allows HPS to deliver added value. Kjølberg relates an example where the data proved to be especially beneficial: "The vessel left the yard after [having antifouling] applied, at 65rpm, which is normal trade. Then they dropped down to 59 because of slow steaming, and they were doing turbocharger cleanings because the speed is too low and they needed to blow off some of the soot. They went back to 65rpm, and they couldn't understand why fuel consumption was sky high. It was because they continued the same process – every single day they did turbocharger cleanings. They couldn't pick it up because they were just using noon reports; you just see that operation is average, but fuel goes up. If you look at high-frequency data, you can see all the peaks. We told them that they could save US$85,000 a year just changing that kind of policy."

Fleet-wide contracts

Over the seven years that HPS has been offered, Jotun has been building up a reference data bank, making it possible to show shipowners the kind of benefits they could expect based on vessels with similar operating profiles. Once these benefits are verified on one vessel, Kjølberg says that shipowners then look to opt for HPS across their fleet, which aligns with Jotun's strategy for the concept: "Our success rate is measured by the same company re-purchasing, not just on the same vessel next time, but also throughout the fleet." Signing up newbuilds is especially desirable – at present, they make up about 30% of business, but Kjølberg says "now we see the newbuilds picking up again and anticipate more contracts," with owners specifying HPS to yards from the beginning of the contracting process.

With the growth of biocide-free paints developed in anticipation of possible future restrictions on copper use, and biomimetic coatings, Jotun's successful run with HPS may stall in the future as the market seeks alternatives to conventional antifouling paints. However, sweeping regulations aside, as long as HPS continues to deliver significant savings for vessels in the segments for which it is tailored, it will remain popular as rising fuel prices and the cost of ballast water systems and scrubbers puts margins under pressure. *NA*

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