THE NAVAL ARCHITECT

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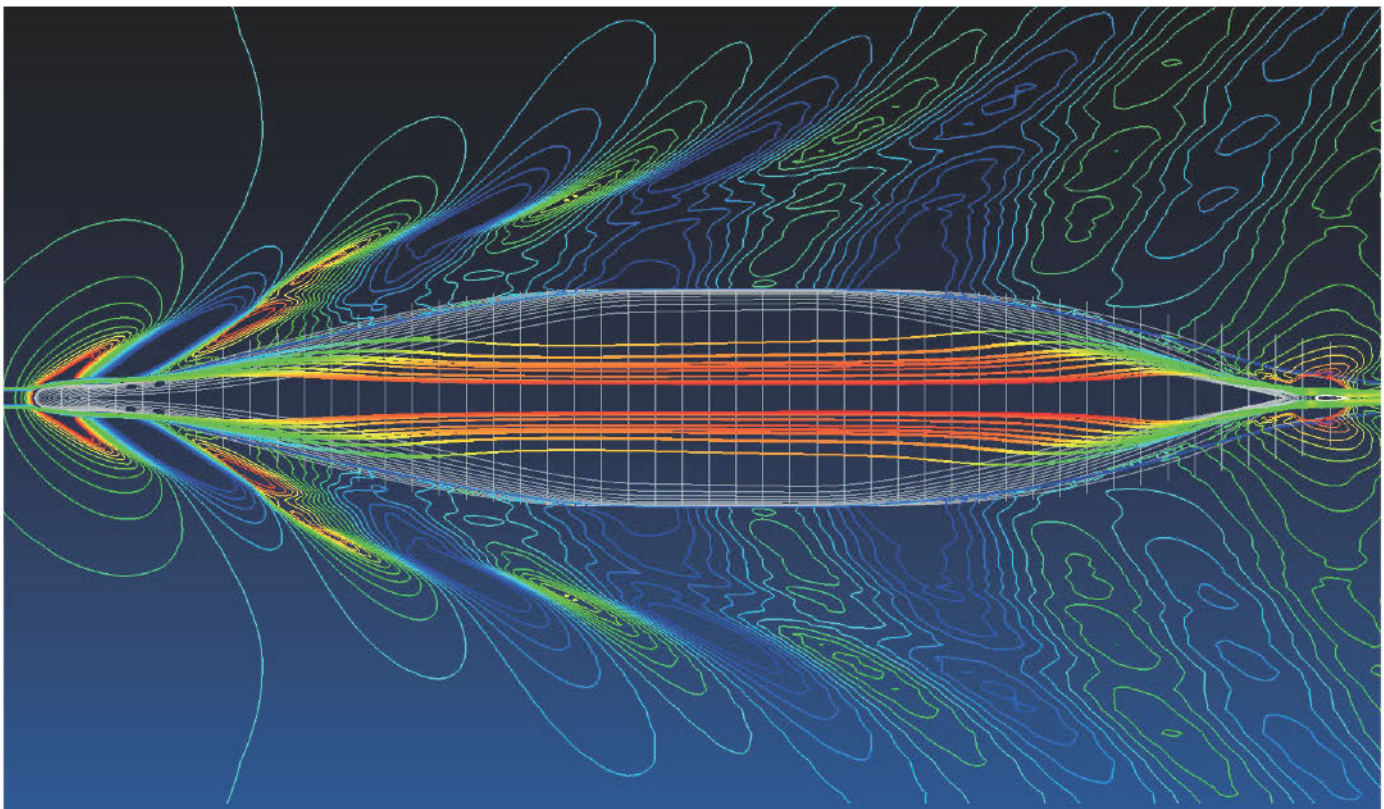

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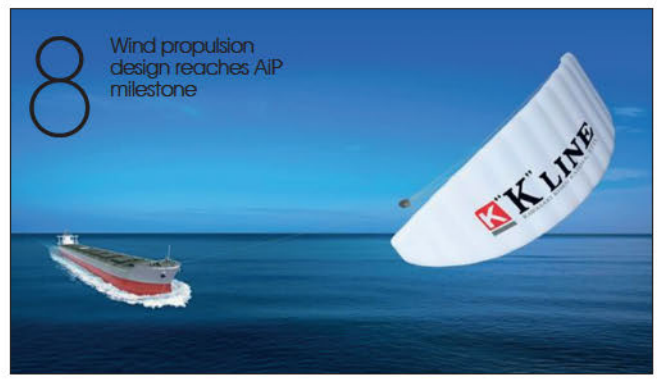

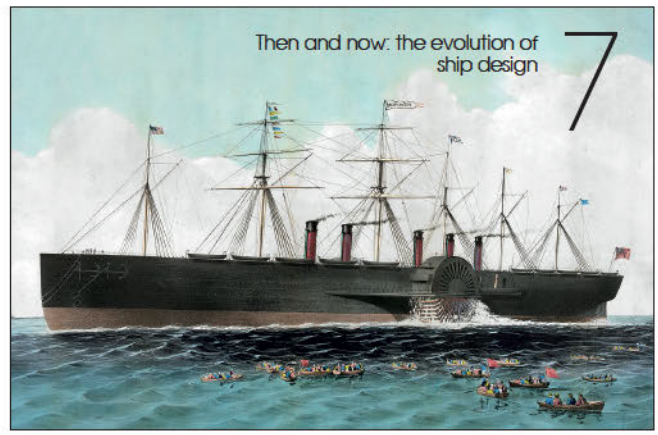

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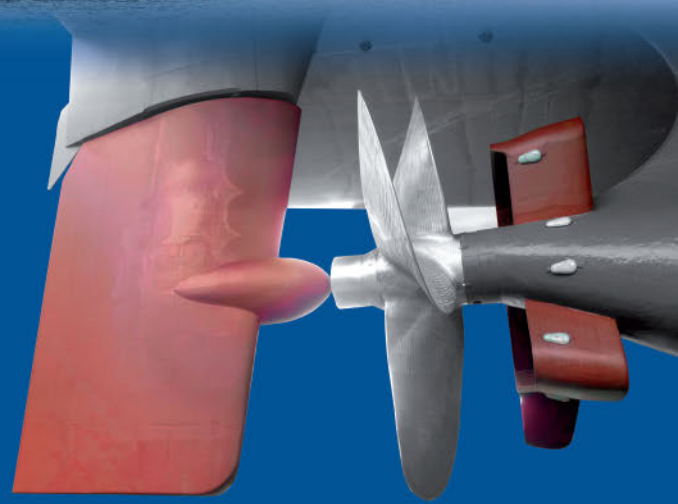

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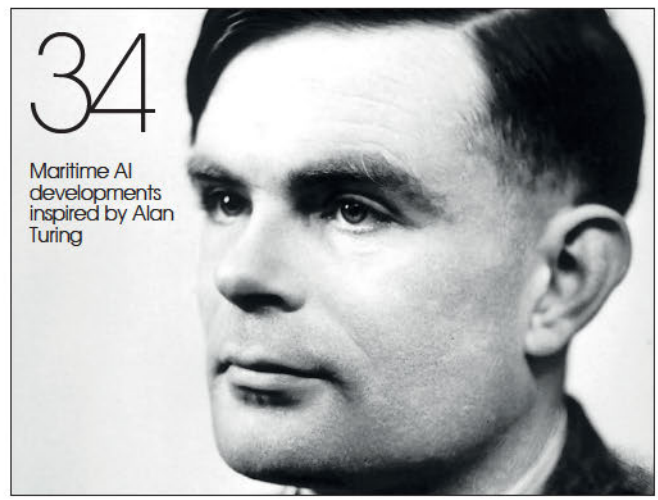
China launches new geophysical research vessel 30



34 Maritime AI developments inspired by Alan Turing

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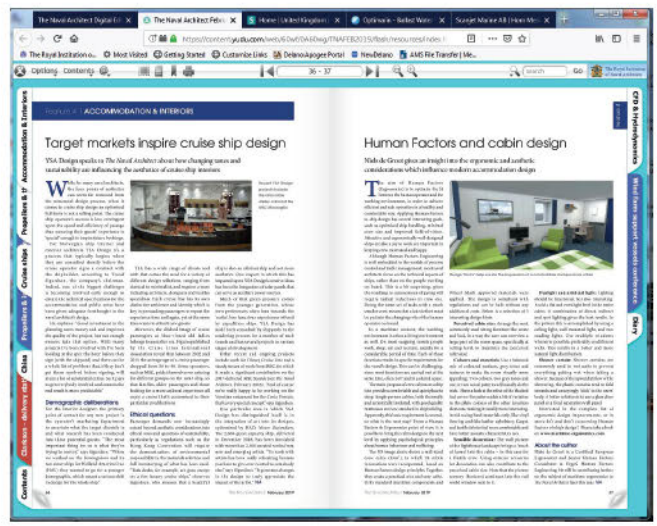
42 Futureproofing cruise ships with cable and pipes



Target markets inspire cruise ship design

Human Factors and cabin design

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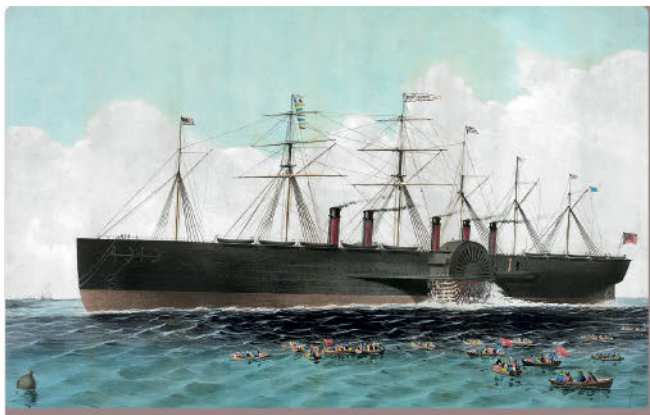


Trailblazer: the SS *Great Eastern*

Back and forth

While 2020 continues to be a strange and uncertain year for all of us, 2021 will be a significant one for *The Naval Architect* as it will mark the 50th anniversary of our first publication. It's an event that we're planning to mark with a number of retrospective articles looking at the evolution of ship design and technology over the past half century, and it's something for which we would very much welcome your thoughts and contributions.

You might, for example, feel that the containerisation of the international liner trade that began in the late 1960s has been the single biggest change. Or perhaps the decline of the European shipyards as they were overshadowed by the rise of South Korean and, latterly, Chinese shipbuilding. Do you think the mandate for double skinned tankers that followed the *Exxon Valdez* disaster, and the ever-increasing influence of regulatory requirements is the dominant theme? Or the rise of CAD and computerisation? It might be something else entirely.

There's probably a habitual tendency for us to look at our own epoch as more remarkable than those which have preceded it. The formation of the Royal Institution of Naval Architects itself was inspired in 1860 by the launch of Isambard Kingdom Brunel's SS *Great Eastern*, a vessel that, with its incorporation of a number of novel solutions, was seen as manifest proof that the steamship, engineered to proven mathematical principles, was more than a flash in the pan. Arguably it constituted a greater advance than anything we've seen since.

If there is going to be a change of comparative scale then it's likely to be in the form of autonomous vessels, but what exactly is meant by that term? As IMO continues with the scoping exercise for Maritime Autonomous Surface Ships (MASS) – a deep-dive into what regulatory amendments may be required for such vessels to operate – we examine how that's redefining our thoughts about navigational functions to ensure that any autonomous system, or the overlap between human and autonomous roles, is completely mapped out and unambiguous.

While the notion of unmanned ships is obviously attention grabbing, it's perhaps not entirely appreciated that the challenge exists less in making these vessels technologically feasible – to the large extent that's already been achieved – as creating an environment where ships of all kinds operate side by side without catastrophic misunderstandings. In some cases, such as COLREGs, regulations will need to be literally written into the coding of these autonomous systems.

One of the things I've found a little surprising – and that I queried with Tomoaki Yamada, manager of ClassNK's Research Institute, during the webinar I attended (p.38) – was why there's not been closer cooperation between the class societies in the development of guidelines affecting the design and development of autonomous ships. Perhaps it's partly that such guides are being drawn up according to the requirements of the specific projects they're being consulted upon, but it strikes me as something of a missed opportunity.

Another area in which it seems inevitable that class will need to become more engaged is the wider applications of AI and machine learning to the maritime sector. Listening to some of the concerns expressed by the various stakeholders who attended a workshop hosted by the Turing Institute's Marine & Maritime Group (p.34-37) it's clear many remain apprehensive about how much access they should grant to their proprietary data, and whether indeed data scientists with no background in maritime will have sufficient expertise to know how to extrapolate meaningful information.

Data is the key to developing effective machine learning applications and it was fascinating to hear how some companies are taking their first tentative steps into this area. While naval architects Olesinski are focused on smaller craft than we would usually cover in this magazine, its foray into so-called physics-based machine learning as a way of 'hacking' the time spent on CFD simulations could be a glimpse into the future. It's something the Turing Group's co-leads, Adam Sobey and Gabe Weymouth at the University of Southampton, are heavily involved in and I hope we can cover it in more granularity at a later stage.

CFD of a more orthodox nature is also covered in this edition and we're particularly grateful to Siemens, Cape Horn Engineering and Friendship Systems for their contributions. Thanks is also due to HSVA for an insight into its involvement in the AERONAUT research project exploring solutions to aerodynamic drag on ship superstructures (p.46-48). It's a reminder of how relatively simple innovations are as important to the ongoing evolution of maritime transportation as the giant leaps of the past, or indeed of the future. *NA*

Wind propulsion

Seawing system granted ClassNK AiP

K-line and French wind technologists Airseas have received joint Approval in Principle (AiP) from ClassNK for the Seawing system's initial design, a concept that utilises an airborne kite in order to convert wind energy into propulsive force.

The overall Seawing system collates and analyses real-time meteorological and oceanic data, then uses the information gathered to adapt its flight path, thereby optimising its performance. The Seawing's kite is designed for easy launch and recovery, as it is switch operated and unfolds, operates and refolds autonomously.

"Seawing reduces the environmental footprint of a capesize vessel by 5,200tonnes of CO_2 per year, depending on the vessel voyage route, contributing to achieving our goal to reduce CO_2 emissions by half by 2050," says Atsuo Asano, VP and executive officer, K-Line.

ClassNK states the AiP is granted in accordance with relevant international conventions and its own class rules, as well as the society's Wind Assisted Propulsion Systems guidelines, which were released in September 2019 to contribute to the safe integrity and design of wind technology and the vessels installing it.

Obtaining the AiP marks the completion of the initial design phase for Seawing's kite structure and controls. K-Line says it will now advance towards development and detailed engineering with a view to the installation and operation of the equipment onboard one of its vessels.

ClassNK has awarded Approval in Principle to the Seawing system's initial design

Container ships

MAIB publishes container ship incident report

The UK's Marine Accident Investigation Branch (MAIB) has published its report into the loss of containers from the 7,024TEU boxship *Ever Smart* during its passage between Taipei and Los Angeles in October 2017.

Ever Smart experienced rolling and pitching with bow flare slamming while travelling in heavy seas 700miles east of Japan. After the rough conditions subsided, it was found that container stacks on the vessel's aft most bay had collapsed and toppled to port. In total, the vessel itself sustained superficial damage, 42 containers were lost overboard and 34 damaged out of the 151 originally onboard.

While the report concludes that the master's decision to alter *Ever Smart*'s passage plan to avoid severe weather and reduce hull vibrations was effective, it also concludes that the incident most likely occurred when hull vibrations and frequency of stern shaking were at their most critical.

Safety issues highlighted in the report include the loss of containers likely occurring during heavy pitching and hull vibration, that the container lashings may not have been correctly secured, and the entire deck cargo bay experienced a loss of integrity due to a combination of factors, including not abiding by the vessel's Cargo Securing Manual for stowage or securing of containers.

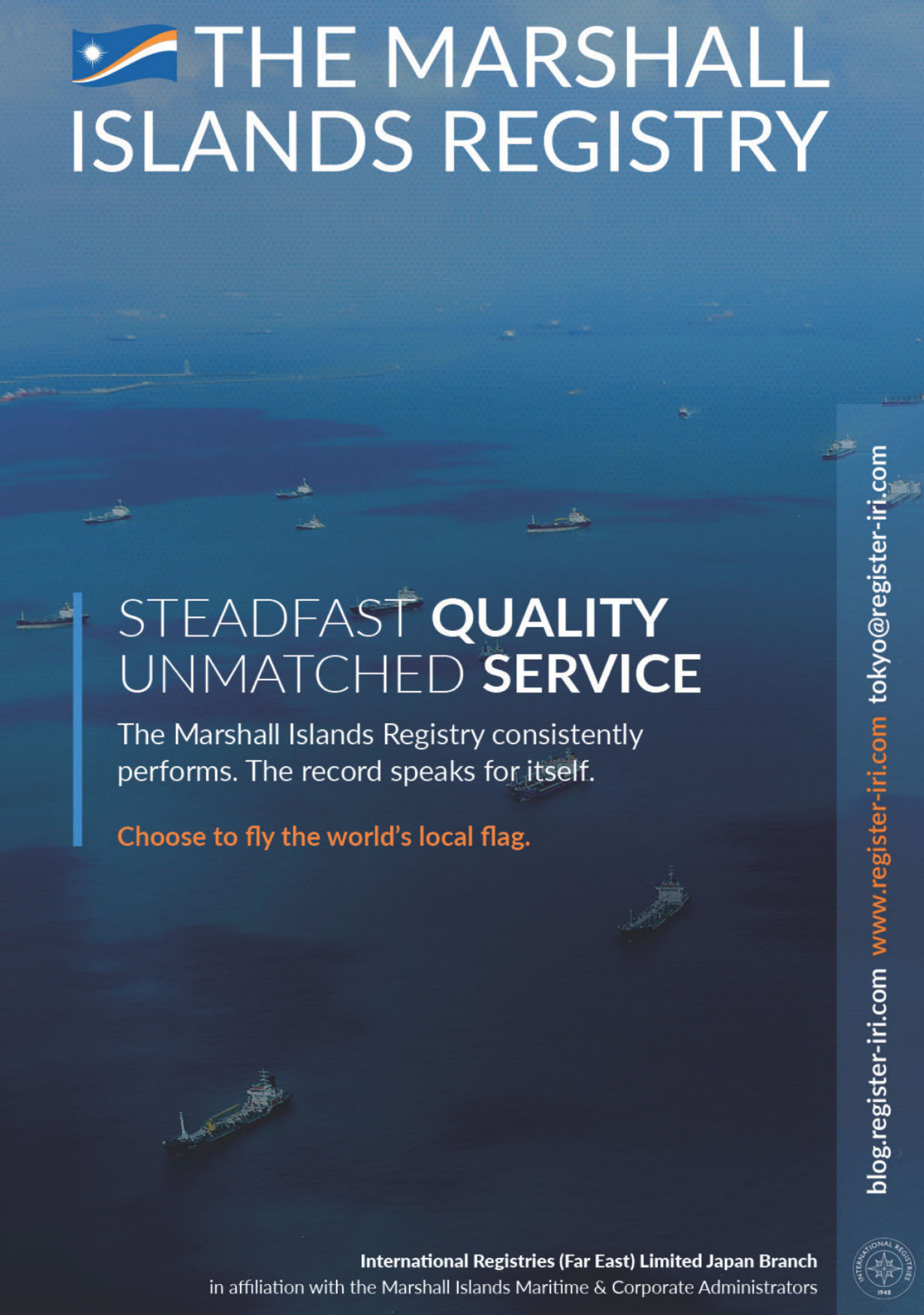
Evergreen Marine Corp, owner of *Ever Smart*, was issued with a series of recommendations with regard to lashing gear maintenance, standards of stowage plans produced ashore and knowledge of bow flare slamming dangers.

Ship design

Naval architects C-Job open Poland office

Independent ship design and engineering company, C-Job Naval Architects, opened its new office in Gdansk, Poland, in July as it seeks to expand its existing activities and pursue new markets in the Baltic and Scandinavian region.

From a design perspective, the Gdansk site will concentrate on functional and detail design, and retrofits and laser scanning. Slawomir Graban, general manager of the new office, comments that: "Combining my experience and expertise in retrofits will bring about new solutions that we can apply to new and existing vessels which will benefit our current and future clients."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C-Job has experience in passenger vessels, dredging, offshore wind and mega yacht sectors, and has a dedicated research and development department, which the company emphasises is focused on innovation and new ways to improve its designs and creative process.

The Polish office adds to its global reach with seven locations worldwide, including its headquarters in Amsterdam and Athens, allowing for greater client support. The company comments that it benefits the end product to facilitate closer involvement of its clients at every stage of the ship design process.

Fleet management

Wilhelmsen and MPC join ship management forces

Third party ship management service provider, Wilhelmsen Ship Management, and asset and investment management company MPC Capital AG, have agreed to combine their technical management of container ships activities.

The joint venture sees Wilhelsen Ship Management acquire a 50% stake in one of MPC Capital Group's technical container ship managers, Ahrenkiel Steamship GmbH & Co KG, which will operate as 'Wilhelmsen Ahrenkiel Ship Management' in the future. The transaction closing for which remains subject to approval by relevant antitrust authorities.

Under its new branding, the company will be supported by Wilhelmsen while continuing its business based in Hamburg, Germany and Rhoon, the Netherlands. Wilhelmsen Ahrenkiel Ship Management's current fleet to manage includes 72 container ships, largely comprising of feeder ships of 1,000 to 3,000TEU capacity.

Carl Schou, CEO and president of Wilhelmsen Ship Management, says that the company aims to develop a strong track record in the container segment together through its partnership with MPC Capital, as well as strengthen its presence in Germany.

He adds: "We believe Ahrenkiel Steamship is a good fit as we share many common values; focusing on quality, heritage and at the same time have ambitious goals to utilise digital technology to enhance and improve the operations."

The partnership between Wilhelmsen and MPC was formalised in an online signing ceremony

Ship recycling

Next phase for Bangladesh-IMO ship recycling project

The Government of Norway has signed an agreement with IMO to continue its support for Phase III of SENSREC, the IMO-implemented project for Safe and Environmentally Sound Ship Recycling in Bangladesh.

Signed on 24 July, the Norwegian Government will contribute NOK14 million (US$1.5 million) as part of the agreement.

The SENSREC project has already successfully completed its first two phases, both overwhelmingly financed by the Norwegian Government; Phase I between 2015-2017 and Phase II 2018-2020. Phase III's 18-month implementation will begin in November 2020.

The project overall aims to guide Bangladesh towards its transition into a party to IMO's Hong Kong Convention (HKC), the treaty which sets worldwide standards for safe ship recycling.

Improving ship recycling standards compliant with the above-mentioned convention, as well as the Government of Bangladesh's capacity building related to legislation and knowledge management, is the central focus of Phase III. SENSREC's third phase also includes technical assistance given to the Government of Bangladesh for the establishment of a treatment, storage and disposal of hazardous wastes facility. Phase III will also consider and evaluate the impact Covid-19 has had on the Bangladesh's ship recycling industry.

Ms Sidsel Bleken, the ambassador for Norway in Bangladesh, comments: "Through IMO, we will continue to support the authorities, industry, and other stakeholders in strengthening their efforts to develop Bangladesh's ship recycling industry and the country's economy." Bleken adds that Norway hopes to see more yards complying with HKC, to allow Bangladesh to accede to the Convention. *NA*

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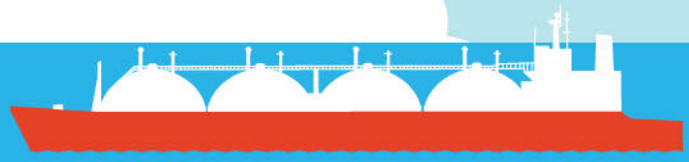

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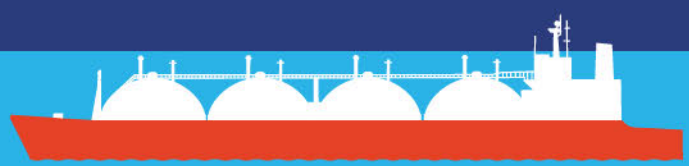

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Slowing growth in newbuilds as world adapts to new order

Malcolm Latarche reflects on the severe knockback the shipping industry is experiencing as a result of the Covid-19 pandemic

Shipping's fragile recovery from the crash of 2008 has been dealt a severe blow by the impact of the Covid-19 pandemic. Aside from the downturn in the offshore sector caused by dropping crude prices in 2015, shipping has generally been doing reasonably well in recovering from the economic downturn over the last decade.

In the container sector, ship size has increased year on year so much so that even Maersk's 18,000TEU Triple E ships once seen as the pinnacle of container ship evolution now look decidedly outdated. Cruising was doing well with leading operators splashing out on new ships and the niche area of expedition cruising burgeoning as designers came up with ever more environmentally friendly designs. The more mundane types such as tankers and dry bulk had their ups and down but generally were doing quite well.

In the space of a few short months all this positive news has dissipated. In early August, BIMCO's analysis of the world orderbook shows that new orders have reached their lowest level since 2003.

Perhaps because so many tankers have been tied up in storing excess oil production, it is the dry bulk and container ship orders that have been most affected. At 63.4 million dwt, the dry bulk orderbook is at its lowest level since April 2004 and 34.7% smaller than 12 months ago. The orderbook for container ships has fallen 10.3% in the past 12 months to its lowest level since September 2003 leaving the orderbook to fleet ratio at its lowest level in many years at just 7.7%.

In the first seven months of 2020, contracting for dry bulk vessels decreased by 65.6% from the start of the year and orders for new container ships are down 37.7%. "Contracting activity has been quick to feel the effects of the pandemic with owners and investors showing little appetite for new ships," says Peter Sand, BIMCO's chief shipping analyst.

Coupled with a drop in orders, increased scrapping is also having an impact. June and July saw a strong uptick in demolitions. Total demolition activity in July totalled 1.8 million dwt, up by 1.2 million dwt from July 2019. Bulker scrapping is up by 80% and container ships by 26.3%. Some 8.8 million dwt of dry bulk and 152,770TEU of container capacity has been sent for demolition since the start of the year.

Despite the rise in demolitions and decline in deliveries in many sectors, the fleets continue to grow because in volume terms, deliveries are much higher than demolitions. The dry bulk fleet has exceeded 900 million dwt for the first time (901.67 as of 3 August), with the fleet growing by 2.6% since the start of the year. The crude oil and oil product tanker fleets have experienced the next highest fleet growth of the four, at 2% and 1.7% respectively, with the container shipping fleet bringing up the rear by growing 1.2% since the start of the year.

Cruise ship scrapping rarely hits the headlines but this year it has as Turkish scrapyards have become the final destinations for the three vessels of the Pulmantur fleet along with *Carnival Inspiration* and *Carnival Fantasy*. Most cruise ships are currently idle and numerous sales are being reported as lines attempt to cut losses. There is likely to be a shaking out of many 1990s-built vessels from all levels of operators.

Away from the impact of Covid-19, the IMO's latest greenhouse gas study has been attracting comment. Although not due to be adopted by the IMO until MEPC 76 and with MEPC still to be held (now scheduled for an online meeting in November preceded by a meeting of the Intersessional Working Group on Reduction of GHG in October) the report prepared by CE Delft has been made public as a working document on the IMODOCS website.

The comments have been the predictable spread of opinion from industry bodies and environmental NGOs. Headlines have focussed on the possible increase of CO_2 emissions from shipping by 50% on a 'business as usual' basis and the revelation that methane emissions from shipping may have increased by 150% in the last six years due to the growing number of LNG-fuelled ships.

Arguably, the true picture will be very different especially as the consensus in the shipping world is that the Covid-19 pandemic may have shifted the foundations of the industry's future as nations re-examine their economic priorities. It will be sometime before that view is proved right or wrong but in the short term the quest to decarbonise continues with ammonia now being seen as the saviour of the industry in the same way that LNG was a few years back. Both Wärtsilä and MAN Energy Solutions are actively working on ammonia-fuelled engines with the latter predicting that it could have a version of its ME-LGIP ready to run on ammonia in 2024. *NA*

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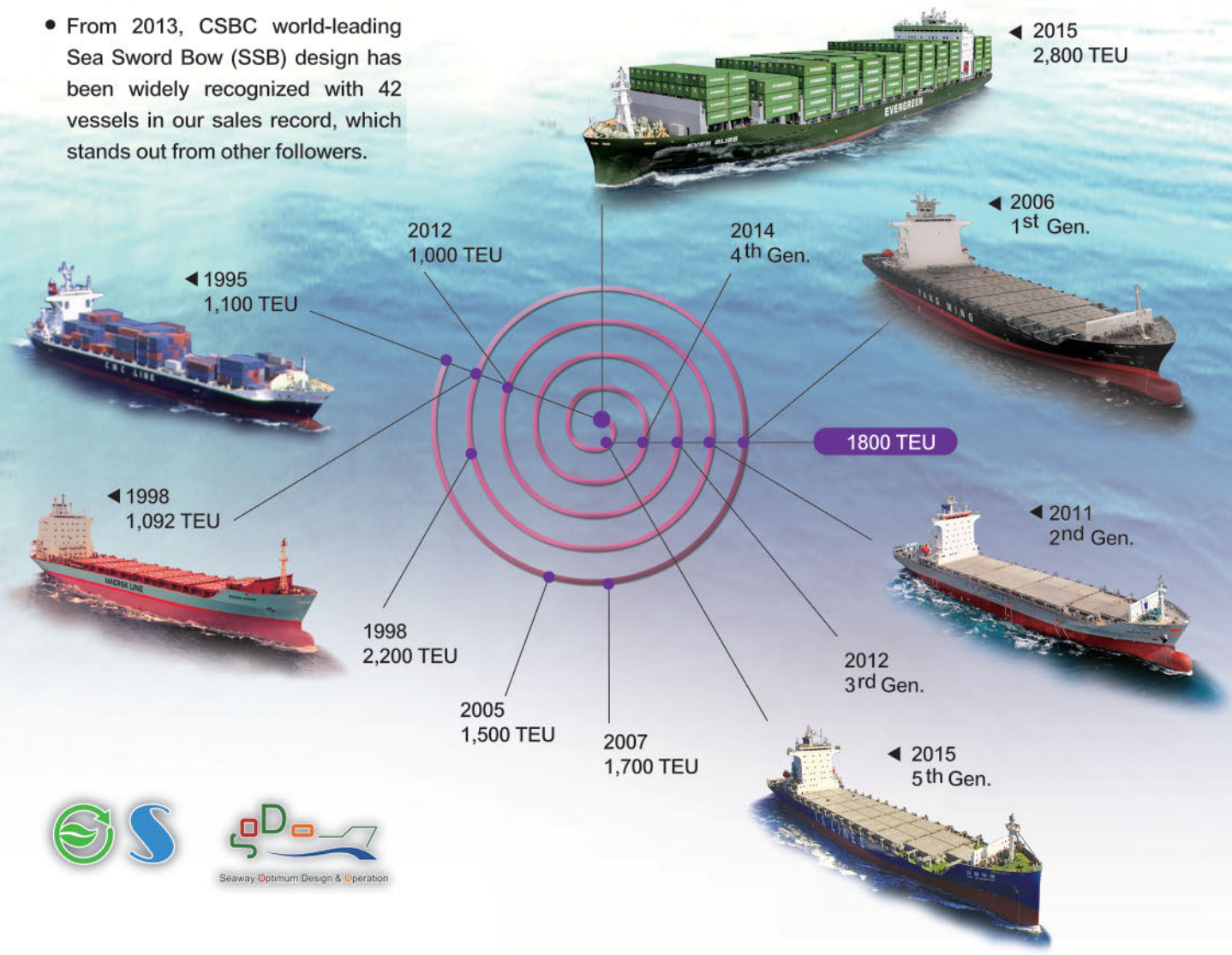

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Propulsion

Schottel launches new azimuth thruster

Propulsion systems specialist Schottel has added new medium-sized azimuth thrusters (M-series) to its range of products.

The M-series comprises multiple rudder propeller sizes with a power range between 400 to 1,000kW and can be produced in three sizes compatible with common engine power classes, 210(640kW), 240(850kW) and 270(1,000kW), all of which feature planetary steering gear. The modular system is adaptable for any vessel design, the company claims, and adds that its azimuth thrusters combine mechanical engineering, hydrodynamic and digitalisation technology.

The azimuth modules are also available for various input directions, Z-drives, L-drives and ZY-hybrid drives, are suitable for horizontal electric, vertical electric and combined direct engines with a horizontal electric motor connection, and compatible with hybrid propulsion solutions.

Schottel's M-series azimuth thrusters can be used by the company's EcoPeller (SRE) for demanding conditions, such as high service speed vessels

Aside from its standard installation with variable propeller arm length, the M-series has a compact minimised variant featuring a shorter propeller arm, known as LC for L-drive and ZC for Z-drive directions. All of which can be bolted, welted or mounted onto a vessel. Schottel claims this frees up more space onboard for other equipment, allowing for ship designers to have greater scope and design freedom.

Schottel has two propulsion modules to utilise its M-series thrusters in multiple operation profiles. Its Schottel Rudderpropeller (SRP) for standard applications and ship designs, providing high bollard pull and propulsion efficiency for medium speed vessels. Whereas its Schottel EcoPeller (SRE) ensures efficiency and course stability for demanding applications and vessels running at high service speeds, such as ferries. The SRE also reduces fuel consumption, emissions and therefore lowers operating costs, Schottel states.

According to Schottel, its M-series, for which first units have been delivered, meets new challenges faced by the international maritime industry, including shifts in engine power classes, updates to ice class regulations and a continually increasing amount of hybrid or electric-powered ships on the market.

Ballast water management systems

Ecochlor attains ballast type approval

Ecochlor has received type approval for its ballast water management system (BWMS) from the Norwegian Maritime Authority (NMA), for the IMO BWTS Code (MEPC.300(72) / revised 2016 G8) standard.

The certification applies to Ecochlor's entire BWMS range, covering flow rates between 500m^3/h and 16,200m^3/h. The company says this allows shipowners to continue installing its systems after IMO's updated BWMS Code (MEPC.300(72)/revised 2016 G8) comes into effect from 28 October. Following IMO's deadline, ships intending to install a BWMS must comply with the international code and meeting the requirements of prior G8 guidelines will no longer be acceptable.

Steve Candito, CEO of Ecochlor, adds: "This latest regulatory approval is another example of Ecochlor's unwavering commitment to obtain and maintain regulatory approvals from class societies and flag administrations across the globe, even as the requirements continue to evolve."

Earlier in the year, the company also completed additional testing on active substance technologies required for full approval in marine, brackish and freshwater environments and concluded that the operation of its BWMS and related equipment requires no further changes.

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Power

Generator turbine and aux boiler orders for MHI-MME

Mitsubishi Heavy Industries Marine Machinery & Equipment Company (MHI-MME) has received orders from Daewoo Shipbuilding and Marine Engineering (DSME) for its generator turbines and VOC-firing auxiliary boilers.

Scheduled for delivery to DSME in mid-2021, the turbines and boilers will be installed in two 124,000dwt LNG shuttle tankers for Knutsen NYK Offshore Tankers that will transport crude oil between the North Sea and Barents Sea. It is the only supplier of both originally designed marine turbines and boilers, the company claims, and will provide its customers with optimally designed products for newbuilds.

MHI-MME states that the generator turbines and auxiliary boilers will be installed to utilise Volatile Organic Contents (VOC) as fuel, as well as minimise hazardous air pollutants discharged from crude oil tanks while its contents are loaded. The company adds that its VOC-firing auxiliary boiler can use both types of VOC; liquefied VOC treated and generated with a recovery device and excess VOC that cannot be treated by a device.

Its VOC-firing boiler's main benefit is detoxifying excess VOC, which MHI-MME states can contain over 80% inert gases, including nitrogen and carbon dioxide, that are difficult to be broken out without a boiler.

The generator turbine, which will provide the vessels with electricity, will lower the vessels' environmental impact through improved energy efficiency and reduced carbon dioxide emissions, MHI-MME claims.

Air lubrication system

Major LNG project orders ALS technology

Silverstream Technologies has received an order for the installation of its air lubrication technology, Silverstream System, onboard eight LNG carriers currently under construction at Hyundai Heavy Industries and Hyundai Samho Heavy Industries in South Korea.

The Silverstream System helps increase operational efficiency, reduce fuel burn and associated emissions onboard, the company states, and estimates that once the vessels are operational the technology will provide impressive net savings.

Of the eight 174,000m³ LNG newbuilds, four are owned by Knutsen LNG, two by investors advised by JP Morgen Asset Management, and the final two ships by Kore Line Corporation. Silverstream says that its air lubrication system is especially effective with the LNG carrier operational profile and hull form and although this order is for newbuilds, is also suitable for retrofit applications.

Silverstream Technologies aims to achieve global reach with its air lubrication system

All eight LNG carriers have long-term charter agreements with Shell, and Silverstream comments that this deal is the latest in its goal to engage with shipyards, shipowners and operators globally. In 2019, the company signed a framework agreement with Shell UK to increase the uptake of the Silverstream System across its LNGC fleet.

Propulsion

Stadt launches new mode for AC grid

Electric propulsion specialist Stadt has launched a new update to its electric propulsion range, Lean Propulsion, which provides a variable generator mode for AC grids and has been collaboratively designed and developed with Pon Caterpillar.

Stadt's VariGrid operates on an AC grid with a variable frequency range between 45-65Hz and regulates propeller speed (RPM) and pitch. It uses three power modes, low, medium and high, which is scalable for propulsion systems powered with up to and above 50MW per propeller. Its technology ensures a more efficient and precise control over power-load and ship-speed for ship operators, Stadt comments, and adds that it allows users to control variable speed from both diesel or LNG-gensets.

This first VariGrid model utilises Caterpiller and MaK products and Stadt states the new feature has improved the overall benefits of its Lean propulsion system. This includes lowering fuel consumption and emissions, particularly at low or medium power, minimising noise level while operating and lube oil consumption, reducing wear and tear on genset and associated maintenance costs, and improving its propulsion efficiency.

Hallvard Slettevoll, CEO of Stadt AS, adds: "In cooperation with leading LNG and diesel generator vendors, we see that with the Stadt VariGrid we can utilise latest generation motor technology to even lower operational cost for our customers." *NA*


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Faststream's 2020 Naval Architecture Employment Review

Mark Charman, founder and CEO of Faststream Recruitment Group, discusses the company's latest maritime global employment review and how Covid-19 has impacted responses

Faststream Recruitment conducted a global employment review of over 5,500 naval architects and marine engineers to gain a unique insight into the views, thoughts and feelings that these individuals have about the industry they work in. It has been a tough few months for many and the company has aimed to establish the impact the pandemic has had on the answers provided throughout.

In a u-turn from 2019, 60% of respondents stated that they were planning on changing jobs in the next 12 months with a further 2% retiring. "There is the potential that if these sentiments are true, employers will need to replace nearly two-thirds of their teams by mid-2021. A 54% increase from 2019 is simply staggering," says Faststream founder and CEO Mark Charman.

Those with the least experience (0–5 years) were the most likely to be planning a move but all experience levels had increased significantly year on year. When asked if the pandemic had impacted their plans to change jobs, 64% agreed that it had. Charman adds: "Not all employers will be aware of how their team is feeling or what effect the pandemic has had on their employees' personal and professional lives. As a leader, it can be easy to get bogged down in the here and now, prioritising crisis management activities of the business and forgetting how life-changing one of the biggest events in history will be."

Respondents were asked how valued they had felt by their employer during the pandemic and 25% felt less valued than normal. "It is not difficult to see how this can happen. Without clear and regular communications from the top, as well as a lack of celebrations of success, it can make employees feel alone and not valued for what they are doing," explains Charman.

Mark Charman

Job security

55% of all respondents had felt concerned about their job security in the last 12 months. Of those planning to move jobs, this increased to 63%. "It is clear that people are feeling insecure about their futures and making plans. Putting aside the anxiety and stress that this causes, it is clear that respondents are getting prepared and being responsive to the situation," says Charman.

But it wasn't just the pandemic that's causing concerns in job security. Employees continue to be concerned about the future of the industry and 37% cited they believed the industry is in decline, exactly as was reported last year. Covid-19 was the second biggest factor with 34% concerned about their job security highlighting the pandemic as the cause.

External factors were not the only cause of job security concerns. Those with three to five years' experience stated that their concern came from the lack of feedback, reviews, or progression plans they had received. Charman adds: "People become concerned about their job security when they aren't receiving the feedback or reviews they are used to. Business leaders, managers and HR face the challenge of being pulled in different directions at the moment. Performance evaluations can take up a lot of time and focus for everyone involved. Many people are simply wary of performance reviews and will do anything to avoid them."

For those who are performing well and exceeding their objectives, not evaluating their performance collaboratively could be one of the worst things you can do. When good or even great performance is not recognised, celebrated or rewarded, it can make employees feel despondent. In the worst-case scenarios, where they feel they have failed to receive the recognition and opportunities they deserve, it can lead to staff turnover.

On the other side, if employees are not performing well, ignoring the situation could be bad for all parties. If poor performance is not identified and talked about rationally, those who need support or better direction can end up struggling and performance decreases further.

An unfortunate outcome of abandoning performance evaluations is the loss of communication and stability that regular feedback enables. Consistent feedback keeps employees on track and working towards agreed business goals, and it also helps them feel a sense of connection which is critical in these times.

Career Progression

The nature of the industry has traditionally offered a structured career path, with clear and specific roles defined by activities and ranked from highest to lowest based on the level of responsibility and pay.

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Faststream questioned if this was still the case and whether employees felt their employer offered good career progression opportunities and 49% believed they didn't.

"For many, moving forward, securing promotions, being offered new challenges is at the heart of why they do what they do. Take this off the table and employers could be in danger of losing key staff who have looked elsewhere for these opportunities instead," says Chapman.

Asked whether they had received a promotion in the last 12 months and only 19% agreed that they had. Of course, it must be factored in that some people will be at the top of their game with no real opportunities on the horizon. However, it is expected that a third receiving a promotion based on the traditional progression levels in the industry, usually with every three or four years of experience.

Chapman adds: "We see more career job-hoppers who feel they need to make a move to simply secure a promotion. This can be increasingly frustrating for employers who have put time and effort into training and sharing knowledge with employees, only to lose them further down the line."

Mental Health

There has been a noticeable shift in attitude towards mental health over the last decade. You cannot avoid a headline at the moment that doesn't mention mental health and the impact the pandemic has had on people. Faststream wanted to go deeper into understanding whether employees believed they had a forum at work to air any issues and asked if employees felt their employer cares about their well-being. Reassuringly 61% agreed that they did. However, this still leaves over a third who don't think they do. "No business wants a reputation that they don't care about their employees. Employer brand is becoming increasingly important when prospective employees are making job change decisions. They want to work for someone they believe in and care about but expect this to be reciprocated too," says Chapman.

When asked whether their employer encouraged them to talk about their mental health, 57% said that they did not. If employees are working in an environment where they aren't encouraged to talk about this important subject and their mental health deteriorates, what do they do and who they speak to? Chapman notes that: "Mental health is not about good or bad. It is about creating a positive workplace culture where it is ok to talk about mental health and to share best practises throughout the business."

Worryingly, 50% said they didn't feel they could talk to their employer about their mental health. Over the last two years employers have developed more robust mental health policies, but there have not been any legal changes to make mental health first aid training mandatory in the workplace.

> "The demand for work-life balance does not mean people don't want to work hard, rather they don't want it to negatively affect their home life overall"

"We believe that businesses that can create, implement and deliver a mental health policy with a trained professional available in the business will enable employees to open up more freely. Mental health affects employees' emotional, psychological and social well-being. Improving dialogue between employer and employee will mean businesses benefit from how their employees handle stress, relate to others and how they make choices," says Chapman.

Work-life balance and stress

In 2019, Faststream reported how important work-life balance was to naval architects and marine engineers, but many felt they were not reaching the equilibrium between the demands of their personal and professional lifes. 75% were working unpaid overtime, while 21% were working 10 or more hours extra per week for no additional compensation. "The demand for work-life balance does not mean people don't want to work hard, rather they don't want it to negatively affect their home life overall," Chapman adds.

Has the pandemic made that work-life balance easier to achieve? Last year, working from home and flexitime were available to 30% and 33% respectively. In 2020, flexitime increased to 35%, while working from home increased to 44%. Initially, it was surprising that this wasn't much higher as the pandemic has forced the majority of employees to work remotely. The only assumption would be that people answered based on the normal practices outside of lockdown.

In fact, 71% believed the move to remote working has meant people are more likely to work additional hours. As mentioned, with 75% in 2019 already working unpaid overtime, how many extra hours is this accumulating to today? How many more hours can employees work before their work quality suffers and potentially lead to burnout?

Naval architects and marine engineers appear to be resilient people, and when the review asked how stressed they felt from 1 to 5 (1 being not stressed) only 12% identified as being 'very stressed'. However, respondents were quick to cite the reasons for any element of their stress. Management was picked as the top pick, followed by market conditions and Covid-19.

About the company

Established in 1999, Faststream is a global people specialist recruiter in the Maritime, Shipping and Offshore sectors. It sources talent for clients across the globe and offers services including permanent recruitment, contract and interim recruitment, payroll services, executive search, benchmarking and salary surveys. *NA*

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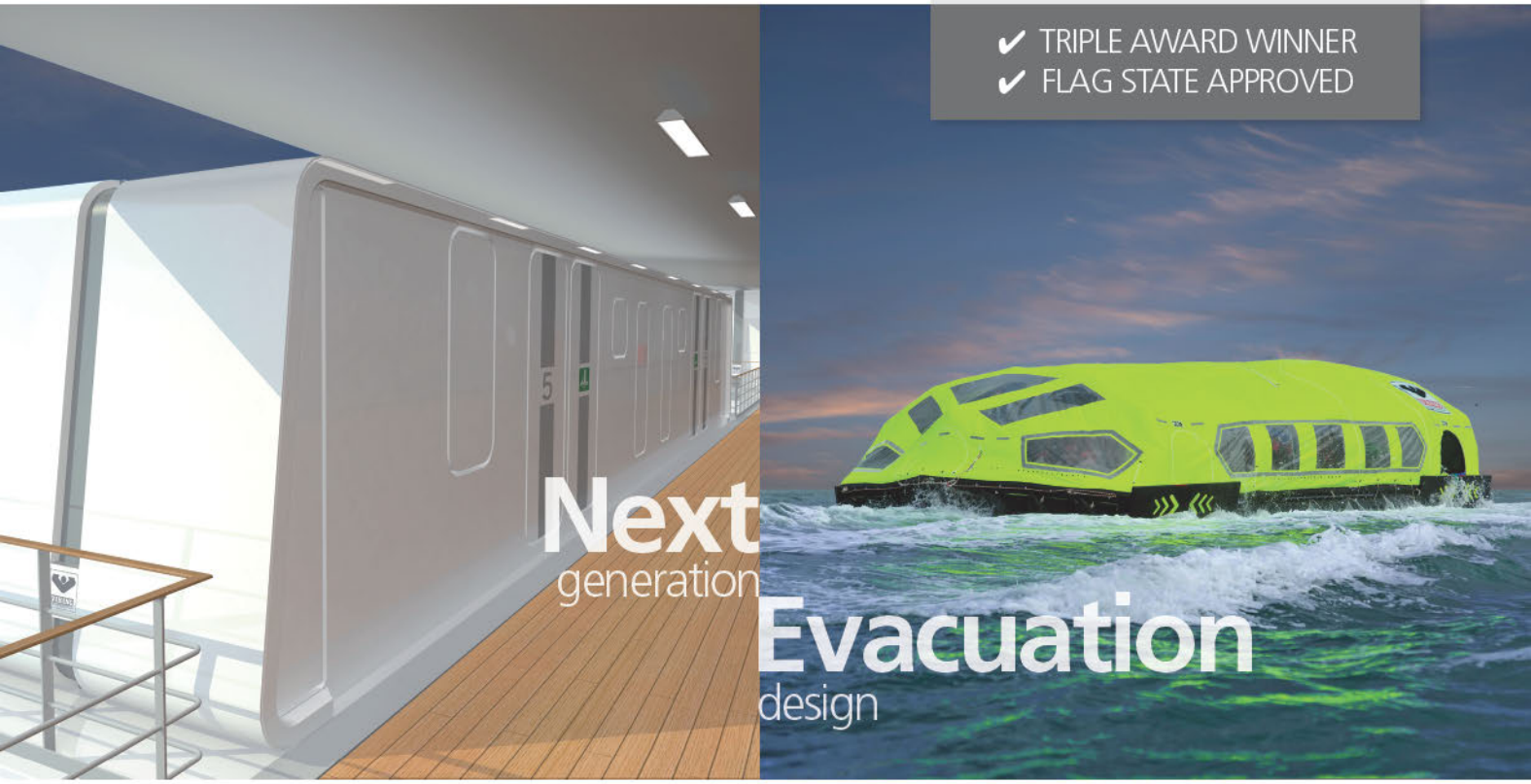

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Can good design help seafarers make better decisions?

A recent webinar hosted by The Nautical Institute argued the case for better human centred design for ships and marine equipment

Mariners will generally find a way to make a system work, albeit not necessarily as the designers intended. Often that leads to discomfort, distraction and even injury. Moreover, as ships grow more complicated, with reduced manning and growing dependency upon the human-machine interface, this problem is only likely to be exacerbated. But what can naval architects and ship designers do to help mitigate this?

"One of the problems of ergonomics is that although the concept is very simple – to make the user the centre of the design – the details for what this means for a particular arrangement of equipment, the procedure for a particular job and how to address the range of people who will do that job involves lots of tradeoffs," explains Dr Jonathan Earthy, technical authority for Human Factors at Lloyd's Register.

Although safe access is a SOLAS requirement and certified by class, the reality can often be somewhat different. Among the examples Earthy uses of design 'fails' is an engine room where it's necessary to stand on the manifold to get access to a wheelhead. In another case, crew are expected to access a winch in a confined space and no protective barriers.

Some fundamental design flaws also find their way onto the bridge. In the example of one recent vessel the maneuvering station on the bridge wing didn't offer a clear view of the shipside, requiring instead the installation of a camera for coming into port. Consequently, the bridge station was effectively useless and crew instead would manoeuvre – via a monitor – from amidships. To compound its problems, the same bridge had a large overheard display panel that not only prevented a clear line of sight from the front of the bridge, but also caused crew to hit their heads and needed additional soft padding.

But Earthy warns that one of the biggest problems is a lack of feedback between operations and design. "If the designer and class don't know what's happening in reality they can't necessarily assure safety."

Now in its second edition, *Improving Ship Operational Design* provides Human Factor guidance for naval architects

"There are many things that could be addressed cost effectively if they were reported," he says. "There's also the waste of money involved if you install a system that's not used or has to be replaced."

Designing for the captain

Dr Capt Margareta Lützhöft, a former master mariner and professor at the Marsafe group at the Western Norway University of Applied Sciences, says the infamous tragedy of the 17th century Swedish warship *Vasa*, which sank due to the weight of its cannons, is a textbook lesson in why "you should build for the captain not the king".

Although the naval architects of commercial vessels may often feel that the dictates of the shipowner take priority, that doesn't have to be at the detriment of Human Centred Design (HCD). In particular, Lützhöft notes the 2014-built vehicles carrier *Harvest Leader*, where 1,716 different changes were made to the design in the interest of human factors and engineering. These included moving the cargo hold fans to improve visibility, cameras installed at critical locations, 'plug and play' modules in the engine rooms and enlarging the crew living and common spaces to increase comfort.

"We're very proud of this ship because the changes were partly made on the suggestions of our own publications," says Lützhöft. "We are still in contact with the naval architects who did this and a lot of these changes were made not during the design stage, which was more expensive".

Ergonomic standards

HCD has been formalised and is widely practised in other sectors of industry and has been standardised as ISO 9241-210 'Human centred design for interactive systems'. Conceived as a cycle of improvement with the objective of understanding what's going wrong, specifying the user requirements, producing and testing solutions and then evaluating the design to determine whether it meets targets (with performance measured by usability). There is then an ongoing process of monitoring to see whether anything changes to affect that usability.

The Nautical Institute's own publication, *Improving Ship Operational Design*, continues to be the textbook of choice to help improve the flow of information between naval architects and seafarers. In addition, the Institute continues to encourage seafarers to show and report poor ergonomics, particularly with regard to the safety, the performance issues it addresses and what can be done to improve the user experience. A comprehensive range of resources can be found at: https://www.he-alert.org *NA*

To view a recording of the webinar visit: https://www.youtube.com/watch?v=L9Ibr-6Ziug.

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Greener and smarter – a think tank for future future shipping

Advanced thinkers from research and industry meet in Cortona, Italy, on 12-14 October to look into the crystal ball at the 12th HIPER Conference (www.hiper-conf.info). Event organiser Volker Bertram previews

The theme is 'Technologies for Future Ships and Future Shipping' for this year's event and it will come as no surprise to the industry that the future will be green(er) and smart(er). But let's have a closer look at what is discussed at HIPER 2020.

Green(er) shipping

The 2020 sulphur cap is old hat. Even the 2030 IMO carbon footprint goals fail to excite me given that we can reach them with existing engineering technology and commonly discussed ideas. But IMO's 2050 zero carbon shipping goals will require us thinking out of the box. They will need ingenuity, entrepreneurship, and boldly challenging the commonly accepted wisdom of my generation.

Looking at the HIPER 2020 programme I am, for once, mildly optimistic. The practical dreamers and creative engineers have come forward, surprising even me with some of their ideas, and most of them proven and matured to at least the prototype stage. SMEs see the challenges as opportunities, and one can only wish them Godspeed.

"If one does not know to which port one is sailing, no wind is favourable," says Seneca. But since the goal is clear, the wind seems to be favourable for sustainable propulsion, most notably when it's wind assisted. Hollenbach (DNV GL) sees 'Wind Assisted Propulsion Systems as Key to Ultra Energy Efficient Ships', and he is supported by two sessions with variations on the theme. Will it be kites, rigid sails, or Flettner rotors? Only time and evolution will tell. Much depends on vendor prices, operational profiles and design constraints. But one thing seems to be clear: if you combine your green sails with a smart routing software, you may double your savings. Green is the new smart; smart is the new green.

Thinking out of the box? The Dutch companies Conoship and Econowind do exactly that. Their sail system is deployed from a container and can be folded away when the winds are not advantageous.

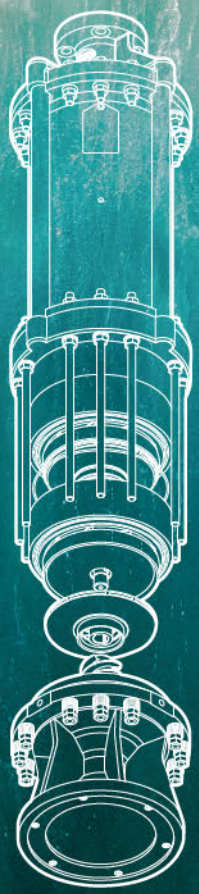
Thinking out of the box: Econowind's wind assistance systems is deployed from a container

Hydrogen drives on

But sustainable propulsion is more than just wind propulsion systems.

Becker Marine Systems bets on sails and hydrogen for zero-carbon shipping (Becker Marine Systems)

RIDE THE WAVE
Of the LNG marine expansion



All the key role players in the marine industry have started to invest in LNG technology and infrastructures, as well as in new dual fuel or gas only engines for ships and new LNG bunkering vessels too. Vanzetti Engineering ARTIKA Series submerged pumps and VT-3 Series reciprocating pumps are the default choice for low and high pressure marine engine fuel gas systems, stripping and spray applications, booster, ship to ship bunkering, cargo and more.

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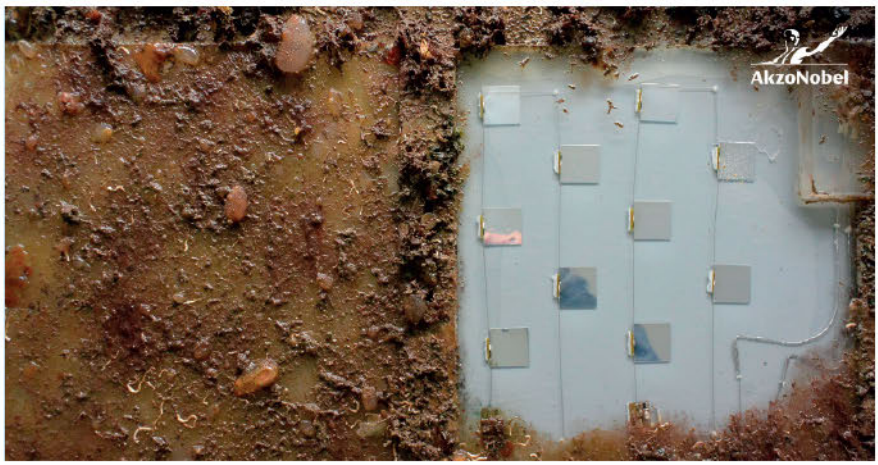


Embedded LEDs prevent fouling through UV light – clever (Philips)

Becker Marine Systems joins forces with Wallenius Marine in a project combining various elements; sails are the most visible and prominent ones, but inside hydrogen is driving the machinery and generating the electricity modern shipping needs.

Hydrogen or ammonia – what will be the future carbon-free fuel? Looking at HIPER, one is tempted to bet on hydrogen. Roy Campe of ship operator CMB shares experience with Hydrogen-Powered Zero-Emission Ship Projects in Belgium, for tugs and inland shipping. And with new fuels come new machinery technologies. Gone will be diesel engines, noise and vibrations.

The future is electric, fuel cells and batteries. The trend is towards more ships adopting it, e.g. expedition cruise ships, and towards larger units, as demonstrated in the German MultiSchIBZ project presented by ThyssenKrupp Marine Systems. Maritime fuel cells offer higher efficiency than diesel engines, but have long start-up times and allow only slow load changes. Subsequently they are usually combined with batteries, where metal-air battery technology enables significantly longer zero emission sailing ranges and lower total cost of ownership.

However, reaching the goal of zero emission shipping is not just about technical solutions, as Teus van Beek (Wärtsilä) points out. It requires a change in mindset and business models. Financing hurdles have to be overcome, for example by pay-as-you-use schemes. Fortunately, such schemes are already evolving and being introduced by some maritime suppliers.

But how will future zero emission ships be designed? In principle, not very differently from how we design ships today. The designs are more innovative than the design process. However, current tools are adapted and as the designs are subject to different constraints, e.g. stability for wind propulsion, the resulting projects are unique. At HIPER, we see databases adjusted for fuel cell machinery, CFD applied to ships with Flettner rotors, and optimisation of electric-propulsion vessels.

Green, smooth, smart

The limelight in the shipping industry is very much occupied by zero emissions. But there is another sustainability topic that draws a lot of attention now in shipping circles: hull management. Part of the explanation of why this topic is en vogue is that IMO biofouling guidelines are due for review, but there is more to it.

The demand for proactive in-water cleaning has risen due to energy efficiency targets over the past five years, but in the same period most ports have clamped down on in-water cleaning due to concerns about invasive aquatic species and accelerated biocide release. Where there is a problem, there is an opportunity. A new world of biocide-free antifouling solutions is waiting in the wings, covered in two dedicated 'Future Antifouling' sessions.

Biomimetics for energy efficiency – New hull coatings developed in Germany (Fraunhofer)

You may have heard of the silent revolution, using ultrasonic transducers, as presented by Jan Kelling (Hasytec). The technology is mature and a good idea for niche areas which are critical for biofouling management.

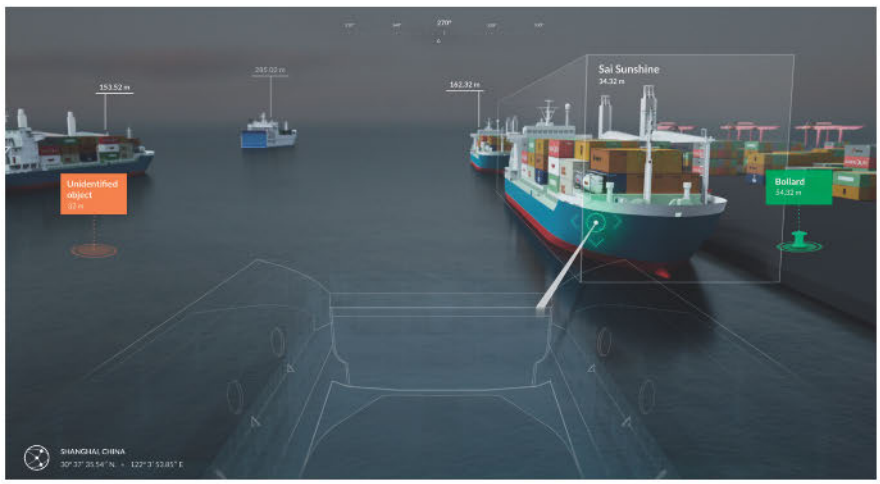
But have you heard of using ultraviolet light? UV is the unseen revolution. Industrial heavyweight Philips has joined forces with paint manufacturer AkzoNobel to develop a novel fouling prevention solution, based on the generation of UVC light by LEDs embedded in a transparent layer.

And there is no shortage of clever ideas on 'passive' solutions. Fraunhofer and Hamburg Ship Model Basin have taken inspiration from Mother Nature. Salvinia, a floating fern, traps air with microscopic hairs. The AIRCOAT technology mimics this, providing passive air lubrication. Another idea is using microscopic (or nanoscopic) surface structures to make adhesion of fouling organism difficult and mild cleaning easy. And while you're at it, why not use latest 3D printing technology for these nano-coatings? Prototype developments from Sweden and Italy will be presented.

Smart(er) shipping

While the 'green' contributions certainly fascinate, they cannot overshadow the 'smart' developments. Emilio Campana et al. (CNR) give an overview of converging ICT technologies, from the Internet of Things to Artificial Intelligence, from everywhere computing to Digital Twins.

The unmanned or autonomous ship is like a pervasive vision on the horizon, a great illustration of how a



Ships and shipping of the future – Unthinkable without A.I. (DNV GL)

multitude of technologies cooperate and cross-fertilise, but also a great example of how the vision is often decades ahead of reality. A key role is played by Artificial Intelligence, 'Maritime Industries' Next Useful Idiot'. Japan's 'On Future Strategy and Technology Roadmap of Maritime Industry' puts high priority on it, Spain's well-known CAD vendor Sener reinvents its portfolio building on IBM's AI software, while ABB challenges the conservative skepticism: Machine Learning can surpass your traditional expertise and yesterday's rules and invite you to 'Believe it or not'. Charismatic business leader and long-term aficionado Giampiero Soncini (IB Marine) not only believes in AI, but that Covid-19 may bring an acceleration of related autonomous technology and marine robotics.

Think tank for modern-day Leonardos

The challenges for future shipping seem sometimes unsurmountable, but as the Chinese proverb says: A journey of a thousand miles begins with a single step. And it is encouraging to see that many steps in the right direction are being taken.

If there is one message to take from the HIPER 2020 programme, it is this: forget the prophecies of doom! The industry is reinventing itself and its innovative drive is impressive. Interdisciplinary expertise and innovative thinking meet this year in Tuscany, a suitable location for the think tank of the modern-day Leonardos. *NA*

Generation next: WinGD unveils the X-DF2.0

iCER, an inert gas recycling system that slashes methane emissions, is unveiled as part of a revamp of its successful dual-fuel two-stroke engines

Since its launch in 2013, WinGD's X-DF has established itself as the world's best selling low-speed dual-fuel engine. To date, there are some 60 vessels in operation and a further 320 on order. The XD/72DF has become a popular choice for LNG carriers, while in May the biggest engine in WinGD's portfolio, the 12X92DF, received type approval for use onboard the very large container ship CMA CGM *Jacques Saadé*.

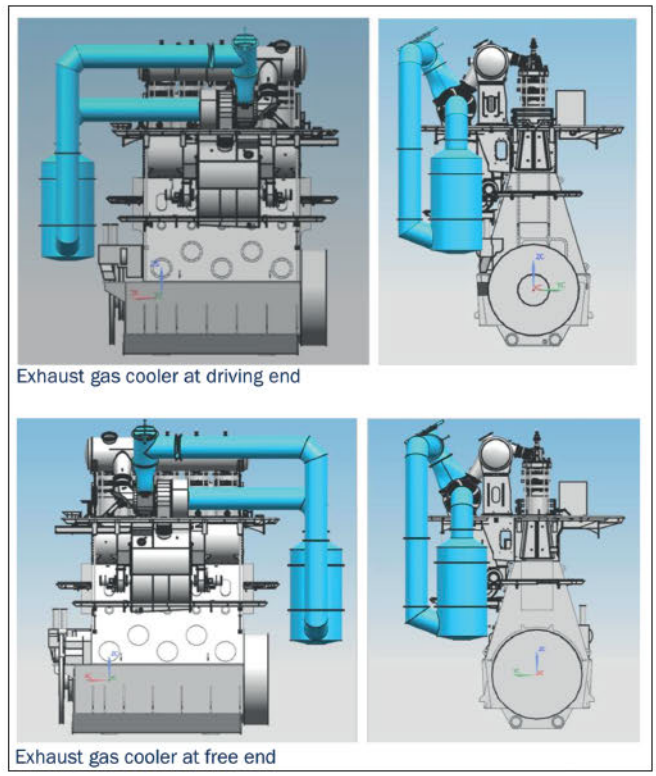
WinGD is now looking to build upon its success with a second generation, the X-DF2.0, developed with greenhouse gas reduction targets in mind and plans to incorporate a number of innovations. In June, the company unveiled the first of these, Intelligent Control by Exhaust Recycling (iCER), an exhaust recycling system that it claims will cut gas consumption by 3%, diesel fuel by 5% and achieve a reduction in methane slip by as much as 50%.

Marcel Ott, WinGD's general manager for operations in China, has been involved in the development of the X-DF series since its beginnings nearly a decade ago. He explains: "The iCER technology reduces the reactivity of the cylinder charge by replacing oxygen with carbon dioxide. CO_2 acts as an inert gas to combustion, moderating the combustion speed, and allows more control of combustion."

In the Otto cycle, iCER extends the operating window between the rich limit and lean limits, meaning the engine can be optimised for the lowest possible consumption and emissions. The low-pressure exhaust recycling path, where part of the exhaust gas is recycled through a cooler into the engine, also allows the engine to operate at higher average mean pressure (BMEP) levels, allowing for a higher power output.

iCER, which is still undergoing testing, will be an optional technology available in two different arrangements. Should shipowners prefer a higher rate of steam production then this can be achieved by adding an economiser which has been developed in partnership with Alfa Laval.

WinGD's VP of R&D Dominik Schneiter admits that the technology has been driven in part by concerns that developments in Otto cycle have been lagging behind those in diesel, while noting that the XDF has already achieved best in class results for emissions and fuel consumption.



The iCER system will be available in two different arrangements

He explains: "This is due mainly to the especially long cycle times we have on low-speed engines. The gas has more time to burn and that means the methane burns longer and there's less methane slip compared to other Otto engines. The unique layering of the gas mixture in the cylinder leads to no flame quenching, crevices or gaps and helps to reduce and keep the methane slip under control."

As the only two-stroke designer that has engines operating in diffusion and premixed cycles in the field, WinGD feels entitled to think of itself as the leading authority on dual-fuel technology. Following successful demonstrations, it has made it a standard for all X-DF engines to be able to demonstrate gas operation down to 5% engine load with minimum pilot fuel.

But according to Volkmar Galke, WinGD's global sales director, the emphasis of the company's research is aligned with industry expectations that LNG should be considered a bridging fuel in anticipation of carbon-free alternatives, such as ammonia, that may become more viable as 2050 draws closer.

Moreover, he believes the X-DF represents the best engine option for 2050 due to its combination of both the Otto and Diesel cycle in one engine, making it capable of handling all fuel types with the appropriate modifications. "The Otto cycle is digesting any gaseous fuel under low pressure, which means that it's low capex. The diesel cycle in the same engine is ready for the liquid fuels to come."

The company is planning additional efficiency features for the X-DF2.0, which it says will be announced in the near future. These are expected to include the variable compression ratio (VCR) technology which WinGD first published details of in a paper for last year's CIMAC conference in Vancouver. *NA*

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CSSC launches new geophysical research and survey vessel

China's recently launched *Experiment 6* meets the nation's need for a medium-sized geophysical research and survey vessel

On 18 July, the geophysical research and survey vessel *Shiyan 6* (*Experiment 6*) was launched. *Experiment 6* was built by China State Shipbuilding Corporation's (CSSC) Huangpo Wenchong Shipbuilding Co., Ltd. It was both designed and developed by the China Ship and Ocean Engineering Design and Research Institute at the Marine Design and Research Institute of China (MARIC) for the South China Sea Institute of Oceanography, Chinese Academy of Sciences (SCSIO).

Experiment 6 is expected to be delivered at the start of 2021. Once it begins its commission, it will become the main scientific research platform for SCSIO, providing advanced mobile marine laboratories and detection equipment for China's marine science research and study of extreme deep-sea environments. Joining a comprehensive range of research and specialised survey vessels, it will jointly support the development of China's marine deep-sea scientific facilities.

The ship is a next-generation 3,500dwt geophysical research vessel designed by MARIC for SCSIO, developed 40 years after its predecessor *Experiment 3* and fills the current gap in China's fleet for a medium-sized geophysical research vessel. It adopts a variety of the most up-to-date design concepts. During the design process, the main parameters such as the total length of the ship, its hullform, the layout of the onboard laboratory and the working deck underwent many rounds of optimisation.

With a gross tonnage of 3,999tonnes, a total length of 90.6m, a fixed crew capacity of 60 people and a range of 12,000 nautical miles, *Experiment 6* is a special purpose vessel with an all steel hull structure, electric propulsion system, active front-end (AFE) frequency conversion control technology, DP-1 dynamic positioning system, and integrated navigation and positioning system.

Design rendering of the new geophysical comprehensive research and survey vessel *Experiment 6*

The ship is fitted with an energy efficient main engine, optimised cabin layout, distributed power load, optimised workflow for scientific research operations and adopts lightweight materials. *Experiment 6* also has advanced performance functions, such as moderate tonnage, flexible operation, powerful scientific research, low fuel consumption and low operating costs.

According to MARIC, *Experiment 6*'s structure and functional design, shipborne control support system, shipborne detection and laboratory equipment, and other facilities are comparable to advanced geophysical research and survey vessels of the same tonnage globally. MARIC adds that the vessel can explore deep seafloor topography at 11,000m, can realise geological structure detection and comprehensive three-dimensional exploration of marine environments.

Specifically, *Experiment 6* has several main design highlights. It's China's first medium-sized scientific research vessel to focus on geophysical surveys as well as taking into account multidisciplinary scientific investigation needs. By comparison with other similar scientific research vessels, it has geophysical survey capabilities and compared with similar geophysical survey vessels has a strengthened multidisciplinary scientific research ability.

Experiment 6 is the first domestic Chinese scientific research vessel that adopts the latest and most advanced hybrid cooling D-pod propulsion technology in the world, with high propulsion efficiency, good maintainability and easily satisfies underwater noise requirements.

It is the first Chinese medium-sized scientific research ship for which the living quarters for all personnel onboard are without upper or lower berths, which greatly improves the living comfort onboard. Its optimised open-air operation deck design maximises the ship's utilisation rate with an area of more than 600m², matching up to the level of larger 4,000tonne scientific research vessels and effectively ensuring the space required for deck operations.

Innovative and integrated technology is used on the vessel to control bubble interference, resolving the contradiction between rapidity (high-speed operation) and anti-bubble interference, alongside

a high plated bilge keel and a specially designed seakeeping ship form, *Experiment 6* is capable of excellent wind and wind resistance performance.

Experiment 6 features a variety of advanced vibration and noise reduction measures that ensure its underwater noise emission meets the criteria of DNV GL's SILENT-S and SILENT-A notations. The vessel's emissions fulfill IMO's NOx tier III requirements, as well as the China Classification Society's (CCS) requirements for the Green Passport for Recycling (GPR).

Among scientific research vessels, *Experiment 6* is able to operate at higher speeds, which can effectively shorten its voyage time, allows the ship to carry forward abundant reserve power and greatly improves the vessel's resistance to adverse sea conditions. The vessel also uses advanced AFE frequency conversion technology to effectively control harmonic interference. *NA*

Robotics and intelligent production in Chinese shipbuilding

The lifting lug intelligent workstation for Jiangnan Shipbuilding's first robotic production line has been put into operation

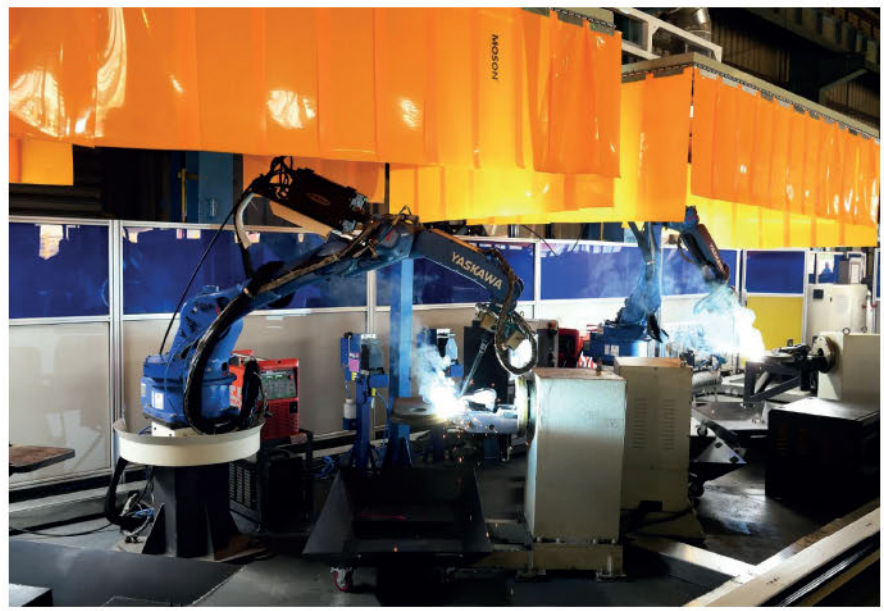
Jiangnan Shipbuilding's first robot intelligent production line's lifting lug workstation officially began its operations on 1 July, marking a breakthrough in intelligent manufacturing for the company, which is a subsidiary of China State Shipbuilding Corporation (CSSC).

A lifting lug is a type of stress-bearing component installed on the ship section or block by welding, or other reliable connection methods, which is used for jack-up, lifting, shifting, turning over and carrying of ship sections and blocks.

In June 2019, Jiangnan Shipbuilding established a lugging workstation research and development project team. After investigating, analysing, demonstrating and testing through trial and error, as well as overcoming problems caused by the Covid-19 pandemic and other difficulties, a year later the project is finally completed and operating as planned.

The overall intelligent lifting lug workstation is divided into three main systems, assembly, handling and welding. Aside from the assembly process, the handling, welding, polishing and cutting processes are all completed by intelligent machinery.

After a single employee completes the assembly of the lug components, the machinery will automatically examine the equipment's model, its placement position and welding position. Following this, it can complete grasping, buffering, transporting, clamping and roll over welding, automatic unloading, and other processes. At present, this system has completely adapted all of the company's existing standard lifting lugs.



Jiangnan Shipbuilding's intelligent lifting lug workstation is in operation

It is reported that Jiangnan Shipbuilding's intelligent lifting lug workstation is the most advanced marine lug production line in the industry, which for the first time integrates robotic visual recognition, intelligent grasping and welding technologies. When put into operation, labour demand will be greatly reduced, with an original 27 personnel team reduced to five, and the consistency of the lifting lug's production quality can be maintained.

In recent years, Jiangnan Shipbuilding has persisted with its development concept 'Based on the combination of cost and man-machine'. In 2019, a new 5G intelligent manufacturing laboratory was established, as well as 5G network deployment at several production workshops, which laid the foundation for intelligent production at Jiangnan Shipbuilding.

It is understood that, aside from putting this intelligent lifting lug intelligent workstation to service, Jiangnan Shipbuilding's 'digital production line group' and other intelligent production projects are currently undergoing intensive testing. *NA*

Simply a better system

Q: Why do the world's leading ship designers, builders and operators choose Liferaft Systems Australia Marine Evacuation Systems?

A: It is simply a better system.

Safe, reliable, cost effective to own. From the makers of the first direct entry MES, we are the pioneers of the MES industry with a product second to none. Now with nearly 1,000 systems in service, we haven't stopped improving since our very first MES was deployed way back in 1992.

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Technological innovation at the heart of Chinese shipbuilding

China's largest shipbuilding conglomerate, China State Shipbuilding Corporation, is heavily engaged in marine technology innovation initiatives

China State Shipbuilding Corporation (CSSC) has accepted 73 orders for vessels in the first half of 2020, equating to 5.35 million dwt, a 34.2% dwt increase compared to last year, which the company adds accounts for 30.4% of the global market share. CSSC attributes this significant business undertaking to scientific and technological innovation, an area it continues to focus upon, and that it acknowledges as the backbone of China's shipbuilding industry and the leading force in marine equipment development.

CSSC and the China Maritime Safety Administration of the Ministry of Transport signed a strategic agreement to develop the country's maritime and transportation sectors

Last month, CSSC held its scientific and technological innovation conference. Chairman of CSSC, Lei Fanpei, encapsulated the event's core message with his speech, titled: 'Innovation drives development to provide strong momentum for building a world-class shipbuilding group.'

According to the company's conference report, it is stressed that scientific and technological innovation should be placed at the centre of the CSSC's overall development, and in order to continuously move ahead as a world class shipbuilding group innovation should be promoted based on strategic needs and realistic foundations. CSSC commented that, going forward, it aims to focus on what it defines as the key tasks related to scientific and technological innovation, which include strengthening autonomy and control, laying out major projects, promoting industrial development, improving the overall shipbuilding system and mechanisms, strengthening open cooperation, and creating a scientific and technological talent pool.

Within its business, CSSC added that it will strive to create an atmosphere that supports scientific and technological innovation, by strengthening organisational promotion, consolidating investment guarantees, strictly implementing responsibilities and carrying forward a culture of innovation.

During the conference CSSC pointed out that, since the implementation of China's '13th Five Year Plan', and particularly following its major merger between two state-owned shipbuilding corporations in November 2019 (formerly CSSC and China Shipbuilding Industry Company [CSIC]), the company has united and worked hard to gradually improve its system and mechanisms for technical innovation. Its major projects have also steadily progressed, CSSC noted, and added that significant scientific and technological achievements continue to emerge.

The 13th Five Year Plan (2016-2020), published by the Central Committee of the Communist Party of China, is a plan and policy blueprint for the economic and social development of the People's Republic of China, the 14th of which, for 2021-2025, is to be drafted this year.

The plan sets China's strategic intentions and defines its major objectives and within the 13th edition, it aimed, across multiple industries including shipbuilding, to "encourage more of China's equipment, technology, standards, and services to go global by engaging in international cooperation on production capacity and equipment manufacturing through overseas investment, project contracting, technology cooperation, equipment exporting and other means."

This year the shipbuilding group has announced some significant technological advancements through its project work. Back in May, CSSC launched the world's largest marine dual-fuel low-speed engine, WinGD X92DF, which had been independently developed by its recently acquired CSIC subsidiary, WinGD, and built by Shanghai CSSC Mitsui Shipbuilding Diesel Engine Co. The launch could be considered a major breakthrough for CSSC in the field of ship power and propulsion, and it marks the development of the R&D and manufacturing sectors of Chinese shipbuilding's independent high-end marine equipment.

In July, CSSC signed a strategic agreement focused on strengthening the country's transportation and maritime sectors, in cooperation with China's Maritime Safety Administration of the Ministry of Transport. Technology development again falls at the forefront of this partnership, as the agreement covers cooperation on intelligent transportation equipment, marine environmental protection technology, as well as other contributing areas such as maritime policy and technical regulations research and personnel training.

The agreement targets the development and acceleration of high end-marine equipment in China, including equipment for cruise ships, large-scale LNG vessels, and the construction of smart ships and their associated systems. Supporting research into relevant technical regulations is another objective for the joint agreement, in order to provide policy and regulatory support for marine equipment being developed in China, and to accelerate its application. *NA*

Turing Institute explores AI's maritime potential

A workshop for the Institute's recently formed Marine & Maritime Group discussed the challenges and opportunities in developing AI and ML applications

Mention Artificial Intelligence (AI) in the context of maritime and there's perhaps a temptation to think about autonomous ships. Yet it's really just one facet of the ways in which AI and machine learning (ML) is poised to transform marine design, technology and operations in the coming years. However, bridging the gap between the latest advances in computer science and their practical application as meaningful tools is a challenge that requires expertise from outside maritime.

It's a problem shared by many other sectors of industry, particularly SMEs which may have an innovative product or service they feel unable to develop. Providing research support and collaboration in the development of solutions is part of the remit of the Alan Turing Institute, which was founded with government backing as the UK's focal point for data science in 2015.

Following a further recommendation in 2017, and spurred by developments in deep learning and neural networks, the Institute's scope was extended to include AI. Among the academic institutions that became formally affiliated around this time was the University of Southampton (UoS), which earlier this year spearheaded the launch of the Turing Institute's Marine & Maritime Group.

In July, *TNA* was among those invited to e-attend the group's inaugural workshop, an event originally intended to take place at the British Library prior to the Covid-19 pandemic. The workshop's aim was to develop a roadmap for AI in maritime and identify the areas where it can make a difference to the industry, and where the potential challenges may be, as well presenting some case studies from maritime companies that are already taking their first steps in utilising ML.

Alan Turing, the pioneering mathematician, is far from just a totemic figure for the Institute. "Almost all of the work on deep neural networks you can find in papers attributed to Turing written in 1949 and 1950, so some of this work can take a long time before it really becomes useful," says Adam Sobey, lecturer in Engineering and Physical Sciences at UoS and co-lead of the Maritime Group. "Some of these things we need to be working for 20 or 30 years time, while some of them could be making a difference now."

Machine Learning theories that Alan Turing developed 70 years ago are only now being put into practice

Data centric engineering

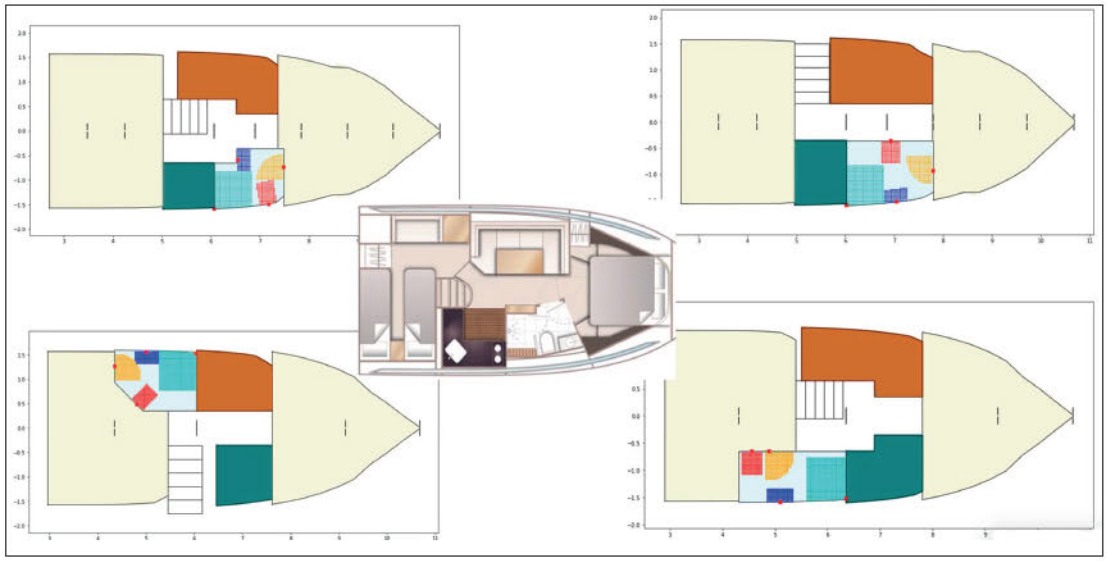
The new group falls under the umbrella of the Turing Institute's Data-Centric Engineering program, an initiative that began when Lloyd's Register (LR) was commissioned to undertake a foresight review on the influence Big Data would have on commercial enterprise, specifically in engineering. A wide range of projects have emerged across various sectors of engineering, industry and manufacturing, focused around key strategic areas, or 'challenges'.

Resilient and robust infrastructure: The increased availability of sensor technology data from critical infrastructure such as power stations, oil refineries and road networks in recent years has raised the question of how to leverage that instrumentation to provide insight. By analysing this data with AI and ML methods the aim is to enhance predictive monitoring and create infrastructure that's more resilient to so-called 'Black Sky' events.

Monitoring of complex systems: Closely related is the challenge of understanding and anticipating rare but high-consequence events. Given that sensor data comes from different sources, at different rates and varying levels of reliability, how can it be exploited for predictive health monitoring purposes? Current projects include the monitoring of cyber and water networks.

Data driven engineering design under uncertainty: One of the program's major research goals is to facilitate engineering that is designed for, and informed by, data. This encompasses issues such as the human-machine interface, but a significant area of focus is the development of Digital Twins and how best to calibrate them to the sensitivity of the instrumentation and extract meaningful insight. The wealth of available data means that classical methods of calculation are beginning to reach their limits of what can be realistically accomplished, meaning that AI-based surrogates are playing an increasingly important role.

Mathematical foundations: In addition to the above, the program seeks to build stronger links between theoretical



Naval architects Olesinski has been using algorithms to explore the interior design space, but ultimately hope to use physics-based ML to speed up CFD. Credit: Olesinski

research and ensure the robustness of the data science solutions developed within these engineering applications.

The program is already working closely working on a number of projects with the aerospace industry, for example a Digital Twin of a Rolls-Royce aero engine that can be used with test rigs. Given that most aero engines are only sparsely fitted with sensors it becomes difficult to form more than pressure and temperature for some cross sections of the engine, and unfeasible to simulate the physics within a reasonable timeframe. Therefore, factors such as subcomponent efficiency and identifying cold spots are important in providing insight that forms the basis for code capable of predicting behaviour. Another project is using AI to verify the safety threshold for engine components made using Additive Manufacturing based on CFD simulations.

Construction is a further area where sensor data is providing insight for modelling behaviour. In one project, a railway bridge has been instrumented with around 160 sensors and software developed in collaboration with Microsoft that provides critical health monitoring and makes it possible to adapt service cycles.

Bringing AI into the design toolset

AI is already influencing ship design and it's by no means reserved for larger companies. Isle of Wight-based architects Olesinski, which specialises in luxury motor yachts, has been working with Adam Sobey's UoS team for a number of years, providing support for student projects and developing areas of mutual interest in AI-related techniques.

"Our current strategy revolves around building a toolset with the ability to rapidly explore the possibilities of a particular hull envelope – in terms of what we can fit into it – while considering structural aspects and exploring the hydrodynamic behaviour of different hullforms," says Bill Edwards, Olesinski's head of R&D.

Unlike merchant ships, in yacht design the emphasis is less upon optimisation and more on the subjective, so search algorithms serve as a kind of screening process to illuminate options of how the space, particularly internally, can be configured before human designers assess which particular options warrant further consideration.

Edwards explains: "We deliberately explore areas of the design space where we know would be considered suboptimal in many respects. So we're able to have quantitative discussions for and against before moving in various directions. This is why developments in genetic algorithms have been interesting to us, as techniques which promote a diversity of searches over convergence are particularly useful in solving these sorts of problems."

Genetic algorithms, a concept which can be traced back to Alan Turing's concept of a 'learning machine', first rose to prominence with the work of the computer scientist John Holland during the 1970's. However, in the last few years the UoS team, with funding from the Lloyd's Register Foundation, has developed the Multi-level Selection Genetic Algorithm (MLSGA). This is based on the evolutionary theory that an individual's fitness for survival depends not only on its own abilities but also the group it belongs to, for example a wolf and its pack.

Applying the MLSGA serves as a method for dividing the design space into smaller constituent parts and then exploring different iterations of those parts more rapidly. In other words it becomes possible to create a greater number of complex architectural models rather than spending time on research and feasibility. This makes it particularly useful for investigating the diverse possibilities for the yacht's interior space and then cherry picking the best options to show to the client. After inputting the hullform, the calibration of Olesinki's software with any explicit parameters is a simple matter and a series of different possibilities can be generated within minutes.

More ambitiously, the company is also working with UoS on developing physics-based ML as a means of 'hacking' the time spent running CFD. Given the limited insight it provides as to why a given set of parameters is performing, it might be as effective to use the flow field data from a handful of simulations rather than the grander DOE technique to inform a numerical surrogate.

Edwards says: "Those flow fields are informed by the initial simulations that

have been run for checking things such as mass conservation, which is where the physics-based part of the name arises. We're constantly checking the validity of the estimates that arise from this model, and working towards flow fields that may be more valid by using the normal physical quantities that we would be checking in the course of a CFD simulation. The upshot of this is it should allow us to predict flow fields around a hull that hasn't actually been simulated.

"The other really exciting thing about using these techniques is that multiphase simulations are so time consuming because we start from a very general initial condition… you've got to wait a significant amount of time for some flow features to develop organically. By using a flow that's been estimated using these predictions and feeding that into the solver to act as the initial condition we can arrive at a result very similar to that if we'd run it from the very beginning."

While it potentially offers a tenfold speedup time it remains a work in progress and Edwards admits there is a lot of development to be done to reach the point where full parametric optimisations can be performed using these techniques. Moreover, the types of CFD simulations are continuously becoming less expensive both in time and cost in their own right due to the rapid advances with solvers. But he remains convinced that in the future physics-based ML will have a place in the naval architect's toolset for optimisation/exploration studies.

"For us the aims are clear; to be able to perform broader and deeper explorations into the potential of a design so that options can be explored at an appropriate point in the design process, in time for key decisions to be made with as much information available as possible."

Olesinski has already presented at a number of events and seminars about the work, to considerable interest and the intention is that these enhanced tools and techniques will be marketed under the brand OlesinskiAI.

Performance optimisation

Another player exploring the possibilities of AI and ML, but for ship operations and fleet management, is oil major Shell. As a company with a large maritime footprint and a stake in anything up to 2,000 different vessels on the water on any given day, the incentive to be at the forefront of efforts towards safer and more efficient shipping are self-evident and in 2016 Shell started upon a strategy of digitalisation.

"Some of the more complex data we receive from our assets we wouldn't have been able to understand or make any insight into without the help of ML or AI technology," explains James Heliwell, fleet technical excellence analyst for Shell Shipping and Maritime, in a follow-up conversation with *TNA*.

Shell's wider digitalisation strategy includes the development of solutions using technologies such as 3D printing and VR, and like many companies it is exploring the possibilities for remote surveying. But it's with the capability to start processing the data from onboard sensors that AI is proving particularly advantageous.

Until very recently, the reporting of onboard data had scarcely changed in more than a century; it was principally the noon report. Onshore analysis of vessel performance was reliant on crew going around the engine room and physically reading the gauges and sensors, writing the data down on a clipboard and then radioing or phoning it back. While the advent of email did help with some speedier exchange of information it was clearly way short of the Big Data required for meaningful analysis. Only in the last five years, with the advent of the Internet of Things and the constant streaming of data from ship to shore has such a tool been possible.

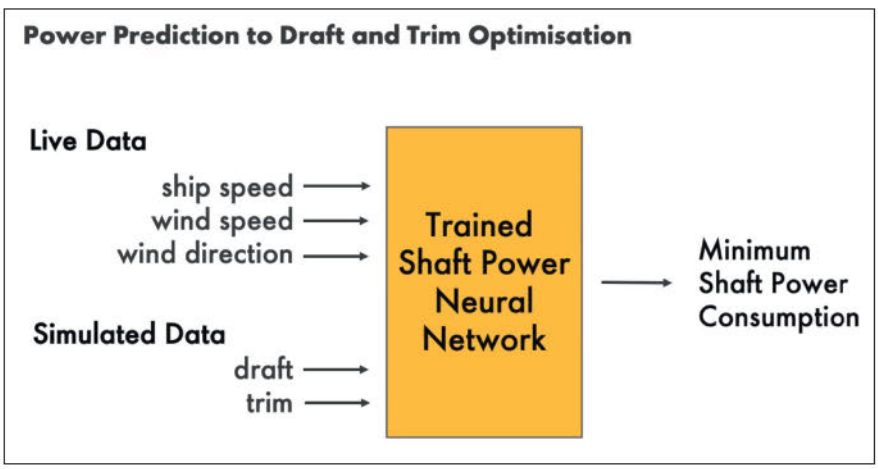
Shell Shipping & Maritime has developed a draft trim and optimisation program that is currently being deployed across 50 oil product carriers and 12 LNG carriers in its fleet. The program uses a software tool known as JAWS (Just Add Water) which initially worked off a statistical model using noon report data, before high frequency data sensor data became available.

"The thing that surprised us is that a data driven approach hadn't been developed before," says Helliwell. "Historically, CFD hull models were used to try and determine the optimum hydrodynamic condition. By using real data from the vessel in service, we can also capture the changes in vessel performance over time, such as the changes in hull fouling, to get more accurate results."

Over the past year or so, as part of an ongoing collaboration with UoS, Shell has been moving beyond the statistical model towards an AI-based tool which takes some of this data and feeds it through a neural network to make predictions. In other words, using ML to model the powering of a vessel through the interaction of the different variables.

With the aid of specialist human analysis of the raw data to help 'train' the neural network, it has been able to estimate within 2% error of the actual measured shaft power. Inevitably, there are certain problems that can arise with the reliability and accuracy of some sensors, particularly on older vessels, and these still require intervention until the neural network has

Combining simulated and actual data to calculate shaft power consumption. Credit: Shell International BV



a better understanding of such anomalies.

Nonetheless the model is currently undergoing final validation with the aim of deploying the AI-enhanced JAWS across the Shell fleet later this year. For the present JAWS is intended as a decision support tool for crew, but unsurprisingly the eventual aim is to remove the human element altogether and fully automate draft and trim using the neural network.

Helliwell admits that an optimised ship may count for little, or even be suboptimal, if similar initiatives aren't implemented across the wider supply chain, something that will require increased standardisation and sharing across data platforms. It's something Shell is keen to promote as part of its wider commitment to decarbonisation, including the recent publication of its 'Decarbonising Shipping: All Hands on Deck' report (jointly published with Deloitte and available at: www.shell.com/DecarbonisingShipping), which sets out a path for emissions reduction.

"One of the key solutions identified by the industry in the report was improvements in operational efficiency. Our work on developing JAWS is an example of the work that Shell are doing on this," he concludes.

Plenary sessions

In addition to presentations the workshop also gave ample opportunity for delegates to discuss their own thoughts about the role of AI. The consensus was that most maritime companies using ML tools are doing so reactively, fitting it into their existing processes rather than embracing radical change. In some cases still there appears to be a chicken and egg quandary about whether the tools (i.e. algorithms) are needed first, or the raw data.

When that data is being derived from sensors there are also concerns about whether it can ever be entirely trusted, or completely consistent. While it's not uncommon for a fleet to include vessels of 35-40 years old alongside newbuilds, sensor technology is advancing so rapidly that they typically have a lifespan of less than five years and it's impractical to re-instrument equipment so rapidly.

Another misgiving expressed was the provenance and security of that data. Given that many companies, whether naval architects or ship operators, don't have the in-house expertise to develop their own data analytics and are often reliant on third party specialists. But if that data is being sourced from elsewhere how can its authenticity be verified? And if that data is the intellectual property of the maritime firm then can the third party be trusted?

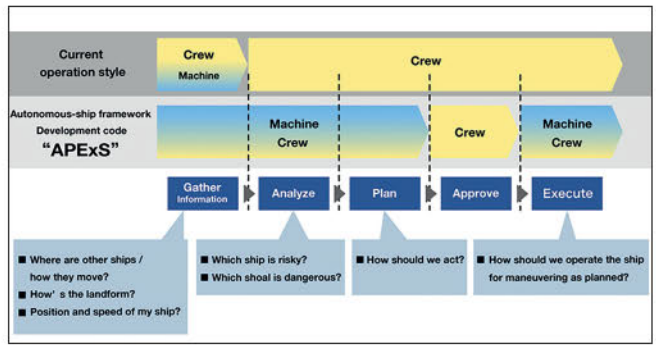
"Do you bring in computer scientists who don't have the maritime knowledge, or try and teach these tools to naval architects?" asks Sobey. "Hopefully that's something that universities can start to change. Much like when coding came in originally you had coders and engineers, whereas now you just have engineers who know how to code."

The Turing Maritime Group aims to publish and circulate a report based on the workshop in the near future. Sobey says: "The idea is that we want to use it to start conversations and help academics get grants from funding bodies, and start to work out whether there are fundamental joint industry projects where people might gain, as well as things like education. There are lots of things that can come out of this." *NA*

Building an infrastructure for autonomous systems

Creating a framework that can facilitate the design and operation of autonomous vessels is a multifaceted problem

Long before the disruption of Covid-19, 2020 was intended to be the year in which IMO would complete its scoping exercise to determine how safe operation of Maritime Autonomous Surface Ships (MASS) could be regulated. Originally agreed upon at MSC 100 in December 2018, the scoping exercise is intended as a root-and-branch review of all IMO instruments and to decide which of these would be affected by MASS, apropos of any regulatory amendments.



NYK and MTI's Action Planning Execution System (APExS) framework is a tool for distinguishing between the roles of humans and machines in a MASS system

MSC 100 was also significant in establishing the four different degrees of autonomy that would fall under consideration, ranging from decision support tools (Degree 1) to a fully self-determining ship (Degree 4). But for the wider industry there remains considerable uncertainty about autonomous ships.

"When I meet people I very often have the feeling that we're talking about different things," laments Capt. Eero Lehtovaara, head of regulatory affairs for ABB Marine & Ports (and current chair of the One Sea multi-company partnership).

In an attempt to establish some boundaries to the discussion, ABB has internally developed its Intelligent Ship Initiative, which is less focused on speculative thinking about autonomy than the practical aspects of onboard operations and the synergy between humans and technology.

Lehtovaara says that one way of framing the discussion is through navigational functions. A bridge crew's situational control depends upon detecting, recognising and registering (whether in the log book or mentally) changes and then analysing and acting upon it. Many of these tasks are already not only supported by navigational tools (ECDIS, radar, GPS, AIS, Gyro) but the use of such equipment is actually mandated under SOLAS.

"I think one of the key elements is whether we would be confident in letting machines take more space. We have already given them a lot of room on the bridge and the engine room. We already have unattended machinery spaces and I don't see why that couldn't also apply to the bridge."

As a technology provider, ABB clearly has a keen eye on the evolution of those social attitudes and how that shapes the markets and demand for new innovations. "One of the discussions we have had both internally and externally, is how the ship systems and subsystems need to be as safe as conventional ships. But there are a large number of unanswered questions in several different areas and we need to pursue this step by step," says Lehtovaara.

Autonomous guidelines

Another organisation putting the onus on how autonomy will affect onboard operations is ClassNK, which in January published an updated version of its guidelines for MASS. Anticipating that the design and development of MASS technologies will assume many different forms and concepts, the guidelines cover common basic requirements and procedures from the viewpoint of safety verification at each lifecycle stage.

"Our guidelines can be applied to most technologies. Whether for concept ships with short navigation routes, whose main goals are unmanned navigation, or oceangoing ships whose main goals are high-level assistance to crews," says Tomoaki Yamada, manager of ClassNK's Research Institute.

As 'proof of concept' Yamada explains how ClassNK granted an Approval in Principle (AiP) to NYK Line and Monohakobi Technology Institute (MTI) for their joint project to develop an autonomous ship framework. The Action Planning Execution System (APExS) is a tool for realising MASS that can support crew members' situational awareness.

In verifying APExS, the target task of the Automated Operating System (AOS) needed to be defined, along with clarifying the roles of humans and computers and the Operational Design Domain (ODD) of the AOS. In addition, there needed to be a clear fallback procedure should the AOS fail.

ClassNK is now working on what Yamada describes as its next contribution to autonomous guidelines: the utilisation of simulation methods and the quantitative evaluation of the results of simulation scenarios.

"When it comes to the simulation the type of situation is important. It is necessary to have scenarios including encounters with other ships, as well disturbance from the weather and sea conditions and so on," says Yamada.

In addition, ClassNK is developing methods for confirming the validity and integrity of Remote Operation Systems (ROS), which will clarify the safety requirements for communications stability. It is hoped these requirements can be established with the help of knowledge gained from demonstration projects. *NA*

MASS communications

Can the connectivity needs of unmanned vessels be met? Inmarsat's head of digital maritime is confident, but suggests there may be some challenges for unmanned remotely operated vessels

The importance of connectivity for Maritime Autonomous Surface Ships (MASS) goes without saying, but it's worth remembering how reliant today's vessels already are for ship-to-shore communications. A large operator such as Maersk Line, with around 275 modern vessels under its ownership and management, already downloads around 30 terabytes of data per month (around 110 gigabytes per vessel) from onboard sensors.

In effect, these vessels are already operating at 'Degree 1' of IMO's MASS definitions, in other words they utilise some automated processes and decision support tools, albeit that crew are onboard and continue to man the bridge. But from an operational perspective, the benefits are already being felt in terms of fuel savings, regulatory compliance, cargo tracing and crew welfare.

"Shipowners and managers recently surveyed say digitalisation brings more than 30% savings (an average of US$10 million) in operational efficiency," says Marco Cristoforo Camporeale, head of maritime digital for satellite communications provider Inmarsat, noting that the company's own Fleet Data IoT platform is one such service enabling this.

When it comes to 'Degree 2' – remotely controlled vessels with some crew onboard – there will be greater demand upon the global availability, latency and capacity of ship-to-shore communications. Camporeale is (predictably) confident that Inmarsat's dual band Fleet Xpress could amply provide in that regard.

With such vessels there's an assumption that the occasions when the bridge may be permitted to be unmanned will be while at deep sea, meaning that the latency and capacity of communications would be less important. Once the vessel comes closer to shore, in closer contact with other ships, crew are more likely to be navigating or at least on standby to intervene.

Marco Cristoforo Camporeale became Inmarsat's head of maritime digital last year, after more than a decade with Rolls-Royce

"Our seafarers will also have more time for other tasks and here we need to consider the connectivity they will require. We want to provide dedicated bandwidth for specific applications, so that there is a segregated pipeline to make sure that certain vital systems have the connectivity they require," says Camporeale.

The bigger challenges will begin with 'Degree 3': unmanned remotely controlled ships. By definition, loss of connectivity onboard such a vessel cannot be acceptable since there would be nobody onboard to assume manual control. While this risk could be mitigated by having the redundancy of multiple systems, an additional problem is posed by issues such as latency and capacity.

"When we're getting close to port or crossing channels we need to have near real-time control of the ship, so we're talking about the need for several tens of megabits per second depending on edge processing… with live streaming of multiple cameras that have to be piped to shore."

While the problem of capacity is largely solvable, with Inmarsat already offering solutions for cruise ship clients that make it possible for thousands of passengers to stream video simultaneously, scaling that up to cover the global merchant fleet is presently impractical.

But latency, the time it can take to transfer data, is something inherent to satellite communication systems and Camporeale suggests it could mean that unmanned remotely operated ships would always require some sort of autonomous safety mode, at least for situations when the vessel isn't close enough for shoreside connectivity.

In that regard 'Degree 4', the fully autonomous ship, might be the safer solution. Since such vessels would be completely unmanned and reliant on the navigation system the level of connectivity required at sea would be much the same as Degree 2 and there would be none of the latency or capacity concerns of Degree 3.

"We might require a partial degree of connectivity in case of an emergency but it's more a case of managing the situation because the autonomous system is taking the ship into a safe emergency condition. The remote connectivity required is only about giving special commands but doesn't require a full remote control system."

Further blurring the distinction between Degrees 3 and 4, Camporeale suggests a possible scenario is that the autonomous system would hand over to a remote control station once the vessel is nearing port , which would offer the added security of human agency while utilising the lower latency and superior capacity that LTE offers over satellite.

"Inmarsat is currently working towards a single integrated connectivity system that relies on L-band, K-band satellite connectivity and also LTE – with the Fleet LTE solution already available this year – in order to provide a full-fledged system with redundancy that will enable a future fully autonomous ship," he concludes. *NA*

Class capability and smart functionality provide a global view of vessel performance

Digitalisation provides an opportunity to harness existing data in new ways and deliver smart solutions that drive safety performance and operational flexibility, writes Patrick Ryan, ABS senior vice president, global engineering and technology

Even before the start of the Covid-19 pandemic, digitalisation was transforming the maritime industry through the increased use of data and connectivity to improve both asset health monitoring and compliance with class requirements.

ABS had already allocated significant resources to the development of smart applications that could streamline the class process for owners and bring additional functionality to support survey and inspection. The most obvious example is the availability of remote surveys – where the benefits of mobile working have clearly been demonstrated. Prior to the pandemic ABS was already advanced in remote survey. As Covid-19 restrictions grew we responded to feedback from the industry, which was grappling with unprecedented operational restrictions, to develop a comprehensive portfolio of remote services, including most annual surveys.

With these new ways of working, owners need access to data and information to keep their operations running smoothly today more than ever. Investments made in digital capable equipment to support operations or maintenance can also be leveraged to class benefit. For class, this is the emergence of condition-based approaches for survey crediting defined by the ABS 'Smart Guide'.

ABS is using the smart functionality that enables owners to have a broader picture of their fleet and understand issues that could impact their operational plans in the class process now. The goal being enhanced asset availability, increased efficiency and improved safety performance. Class machinery surveys will continue to evolve as health monitoring techniques reach new levels of capability and proficiency in the age of smart equipment. Techniques employing comprehensive solutions to real-time health and performance monitoring will become the norm.

Patrick Ryan

Structural surveys can increasingly be guided by historical data compiled from the vessel's operational profile, while load and damage accumulation exposure based on real-time automatic identification system (AIS) route and weather data information will help characterise structural risk. Surveyors can better understand how to survey the vessel, based not just on a set of rules but also informed by the history of the specific vessel.

Data analytics, including the application of machine learning, will add to traditional survey approaches and help owners make better use of their operational data to help understand and diagnose the condition of equipment and provide a prognosis of the time to take corrective action. Such information will also factor into advanced survey planning.

While it may seem surprising that in today's smartphone era such functionality has not been widely available until now, we think the time is right to apply mobile functionality to such services and make them available securely.

To support the digital agenda, ABS has developed an enhanced client portal, MyFreedom, to enable shipowners to schedule surveys – including remote surveys and audits – and compare estimated fees. The same information is available via the new ABS App, providing shipowners with smart fleet management capabilities. Using the ABS Smart Scheduler tool, we estimate it is possible to book surveys and certification renewals in less than a minute. Estimated survey fees are available upfront, and users can compare costs between multiple port locations.

Beyond smart scheduling, users can also customise access to Port State Control (PSC) history by vessel or fleet and see International Safety Management (ISM) Code findings for each port, linked to vessel performance.

The PSC Control and ISM functions analyse and apply artificial intelligence on both ABS data and global reports, including PSC findings, to provide useful information to a client on specific areas of interest or concern on a port, vessel type, fleet or vessel view.

The PSC tool leverages data gathered from both ABS and non-ABS vessels that have been involved in port state interventions or detentions and offers guidance on potential areas of concern.

Additionally, users can drill down further to see fleet and specific vessels,

ABS has developed its client portal MyFreedom, and corresponding mobile ABS App, to support the digital agenda

observations and trends, as well as export reports to print or save. Additional functionality within the app is the ability to interact and manage customised checklists for PSC data as well as personalising a vessel or port-specific checklist based on available data. These checklists provide a live dashboard of fleet performance, with key observations and insights and can be saved on the app or shared externally.

ISM Code functions offer insights on common fleet trends and allow users to see which vessels in their fleet are the best performers and which are outliers. Visualisation is also provided through the live dashboard of the fleet, with drill-down functionality into an individual vessel view of ISM performance. Mobile app users can also view these vessel-specific observations in comparison to the parent fleet.

Crucially, the smart functionality is designed to learn from the users, meaning that with experience over time, the system comes to anticipate future requirements, simplifying and streamlining the entire class process.

This underscores the potential for digitisation and connectivity, even at this stage of the industry's transformation, to deliver safety, efficiency and operational performance gains for the global fleet. *NA*

Roxtec enables faster refits with no-weld seal system

Flexible, fast and watertight – how Roxtec cable and pipe transits are helping to futureproof the cruise ship industry

When faced with sealing over 6,000 openings for cables and pipes, the builders of TUI's cruise ship *Mein Schiff 6* opted for the Roxtec system. This relatively simple invention was used to great effect on the 98,811grt ship, not only greatly reducing the fitout time, but also adding redundancy for future upgrades.

The biggest challenge when faced with running pipes or cables through structural metal partitions is to make a seal that is totally secure. Each one has to be watertight, gas tight and fire-resistant. Traditionally, this has been done by cutting a hole to the exact diameter of each metal conduit and then welding them into place. This presented several problems, ranging from manipulating intense heat in a confined space to how to remove the pipe again for repairs or modifications.

In the cruise ship industry, deck and bulkhead penetrations have to cater for a wide range of non-ferrous carriers too – from lightweight plastic pipes for domestic services to antenna feeds and fibre optics. High power electrical cables can give additional problems from electromagnetic interference. Making thousands of holes and welds – and then remaking them for upgrades or new technology – is labour intensive and costly.

The answer arrived in 1990, when Swedish inventor Mikael Blomqvist developed his idea for a flexible, low-cost fireproof seal and built the first versions in his residential garage. The concept took off and the company he founded, Roxtec, has since grown to a turnover of US$200 million and the employment of around 800 staff. Roxtec products are now used on a wide range of installations needing dependable seals, from oil rigs to nuclear power plants.

As technology evolves, particularly in the environmental and propulsion sectors, pipes and cables can be altered and re-routed without major cutting or welding operations. This effectively futureproofs a ship. The Roxtec system also allows for additional conduits to share an existing seal with simple modifications. A key advantage is the speed of installation for the cruise ship industry along with the built in redundancy that can be added for future upgrades.

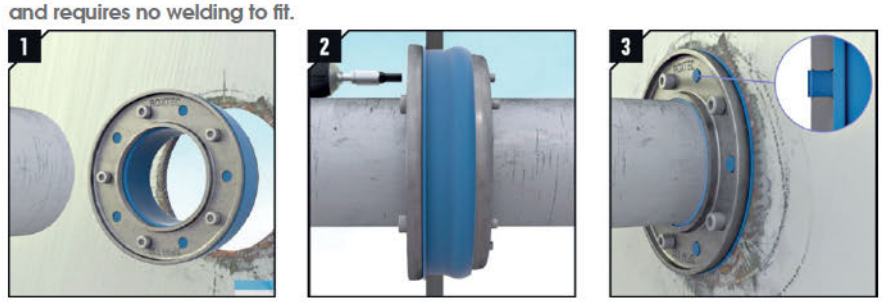
The 98,811grt 295m *Mein Schiff 6* needed over 6,000 conduit transits for protection against water, gas, fire and electromagnetic interference

Roxtec SPM

The company's latest concept, the Roxtec SPM seal, is able to eliminate welding completely and instead support the pipe in a sandwich made of a seal ring of EPDM (Ethylene Propylene Diene Monomer) rubber. This was mounted between two flanges of marine-grade stainless steel, the inner diameter aligns with the most common pipes sizes.

"All you need to do is cut a circular hole in the bulkhead to a prescribed diameter," explained John Kayes, Marine and Offshore Director for Roxtec UK.

The Roxtec SPM seal is an A-Class rated product with DNV-GL, certification and type approval from ABS and RMRS. It can withstand 1bar of water and 0.67bar of gas pressure and requires no welding to fit.



Multiple transits through a single Roxtec seal allows future upgrades for new technology without major works being needed to the substrate

"Then just clean it up, remove the sharp edges and you are good to go. The opening doesn't even have to be a perfect circle as there is sufficient flex in the Roxtec SPM seal. This greatly simplifies installation, plus any maintenance work and even repairs at sea. When using our SPM seals, engineers at a Brazilian shipyard cut installation time by a remarkable 88% and the associated installation costs by 50%. Another job had been assessed as requiring five people, including a painter, a total of 100 hours using welding techniques. That was reduced to just two people and 12 hours using SPM seals."

On the 295m *Mein Schiff 6* over 100 installers were working with Roxtec seals throughout the ship, from the engine room to the pool area. Many of the transits were for lightweight plastic pipes, which presented challenges in terms of fire proofing. Roxtec has always focussed on the integrity of its products and recently developed a new test facility within its headquarters in Karlskrona, Sweden. Here, each prototype seal is placed in a section of bulkhead and subjected to full-scale stressing, especially with fire. The data is captured in real time and there is even a viewing area for interested parties to witness events.

Another helpful innovation for ship builders is the Roxtec Transit Registry, where all the onboard pipe and cable penetrations are digitally logged so the customer can keep track of them. The registry collates all the original penetrations, any upgrades, and also stores the necessary certifications.

For the *Mein Schiff 6* project, key managers found it easy to source the products they needed from one supplier, especially as each design comes with international documentation. At the last count, there were more than 250 registered product certificates and 500 registered approvals.

"The most important thing is to keep up the speed by handling fewer items," said Mika Tuokko, head of electrical outfitting for the ship at Meyer Turku. "By using Roxtec instead of other systems we avoid 50 items in stock for each transit." *NA*

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Seismic survey is an integral part of all the stages of development of oil and gas resources. 2D seismic survey is used for search and 3D seismic survey with high multiplicity is used for exploration and development of oil and gas fields where a detailed geological model of natural deposits is required.

Employment of the conventional technology of seismic survey in freezing seas is possible either during limited ice-free season, or under the conditions of relatively light ice with low ice concentration using additional equipment for deployment of streamer cables under ice cover [1, 2], and with ice-breaking support. It is also necessary to note that the duration of working season for various areas of the Arctic Ocean can vary from two to five months depending on weather conditions and there are times when some of the seas are ice-packed all year round, which makes seismic survey from surface ships infeasible, high-risk and cost demanding.

Therefore, there is a demand for development of new seismic survey technologies. Seismic survey by a group of autonomous unmanned underwater vehicles (AUV) is proposed as one of the perspective technologies [3]. Group of AUVs can be stowed for transportation in standard 20- or 40-foot shipping containers, which would ensure their storage, maintenance, charging of batteries and retrieval of data recorded on AUV memory cards.

This robotic system for seismic survey may consist of one or more sets of technical means of seismic survey and can be designed as a "garage" for launch and recovery of a particular number of vehicles e.g. 200 pcs. (Figure 1). The system is proposed to be controlled from the seismic survey control station located onboard the carrier ship.

It is expected that the robotic system will be operated all year round in the Arctic seas under heavy ice conditions with an ice-class vessel being used as the carrier. To ensure sub-sea (sub-ice) seismic survey in hard-to-reach areas of the Arctic shelf with harsh hydro-meteorological conditions and under ice cover of the Arctic Ocean, it is required to create an AUV generating seismic signals (Figure 2) and make it part of the robotic system.

Use of groups of AUVs and AUVs generating seismic signals will make seismic survey possible in any area of the World ocean. This technology will show its highest efficiency in freezing seas.

Hence, AUVs used for seismic survey will open up new opportunities for exploration of hydrocarbons in the Arctic Ocean and contribute to development of conceptually new methods of seismic survey, individual for specific seismic conditions.

Figure 1 - General view of a group of AUVs launched from the robotic system to form a seismic signal recording platform

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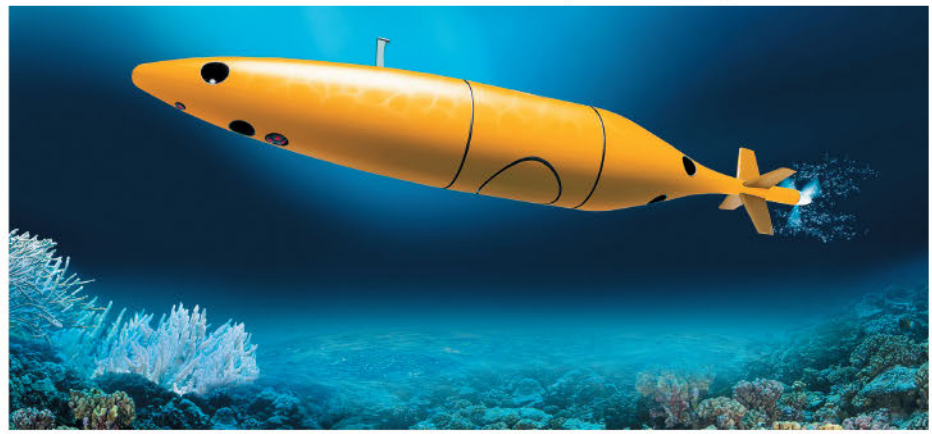

Figure 2 - General view of autonomous unmanned underwater vehicle generating seismic signals

Cheating the wind – at sea

The AERONAUT research project, led by HSVA and funded by the German government, has been exploring ways of reducing the aerodynamic drag of ship superstructures

Authors

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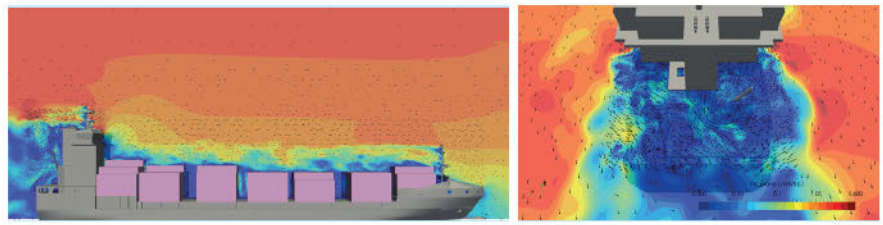


Fig. 1: "Instantanous turbulent flow field in a vertical plane at center line (vxz left) and in a horizontal plane 20m above baseline through the deckhouse (vxy right), obtained from a DES-simulation."

Climate control and environmental regulations call for an ever increasing awareness of energy consumption and associated emissions at sea. The ambitious plans of IMO and the European Union for maritime emission reductions in 2030 and beyond will require a vast range of changes to be implemented in today's 'normal' waterborne transportation processes.

To meet these targets, a change of propulsion technology and specifically fuels will be necessary. Although it is difficult to predict today which will be the winning technology, it is already evident that the new solution will come at a price. This in turn means that the total consumption of costly energy must be kept at a minimum level, and consequently all energy consuming contributions must be revisited. This includes smaller contributors including the aerodynamic resistance of a ship.

Aerodynamic drag on cargo vessels

The wind resistance of ship superstructures is usually classified as low during the design phase. With the exception of passenger ships and yachts, for which comfort is more important, wind influences are rarely considered in great detail. As a result a largely 'cubistic' design of superstructures has been established during the last few decades, mainly due to more cost-effective production processes.

However, the largely rectangular design of superstructures has considerable disadvantages with regard to the wind forces acting on them and leads to an increase in the overall resistance of a ship. The share of aerodynamic drag in the total drag of a ship can be as much as 15% in adverse cases. For a small container vessel used in intra-European feeder traffic, aerodynamics still contribute about 6% to the total resistance while the share for other vessels without deck cargo, e.g. tankers of bulk carriers is much higher.

Inspired by technical solutions mainly from automotive industry, HSVA together with industry partners launched the research project AERONAUT, funded by the German Ministry of Economic Affairs and Energy, to seek for cost effective solutions to improve this situation, investigating a set of promising spoiler and cowling solutions for the most critical areas of ship superstructures causing increased aerodynamic drag. As expected, this analysis resulted in a focus on the deckhouse for a large number of cargo vessels such as tankers, bulk carriers and even smaller container vessels. The left part of Figure 1 indicates the instantaneous turbulent flow field in the (vertical) centre plane (vxz) and in the right part a horizontal plane (vxy)20m above baseline through the deckhouse, obtained from a DES-simulation for a 1,000TEU container feeder vessel which was made available by project partner Jüngerhans. This indicates the loss of kinetic energy on the front side of the deckhouse, which is further underlined by the complex separated flow situation behind the deckhouse shown on the right hand side.

CFD approach

The aerodynamic flow over ship super structures is typically characterised by a combination of several sharp edged, blunt geometrical features which leads to larger vortex shedding. These large, high-energy flow vortices are found in the entire flow field of the superstructures and in particular dominate the wake of the superstructures or the deck cargo. Such flow structures cannot be properly resolved using RANS or URANS approaches typically used in ship hydrodynamic analysis. On the other hand, DES simulations offer a much better insight into complex transient flow patterns arising from the flow over blunt (ship) structures. Validated by careful wind tunnel experiments, the developments in the AERONAUT project led to an efficient and highly accurate CFD flow analysis for the prediction of the aerodynamic flow over complex ship superstructure geometries.

Container vessel test case

The test ship which was made available during the project is a small 1,000TEU container feeder operated by project partner Jüngerhans. Operational data for the ship in standard configuration were made available in the form of noon

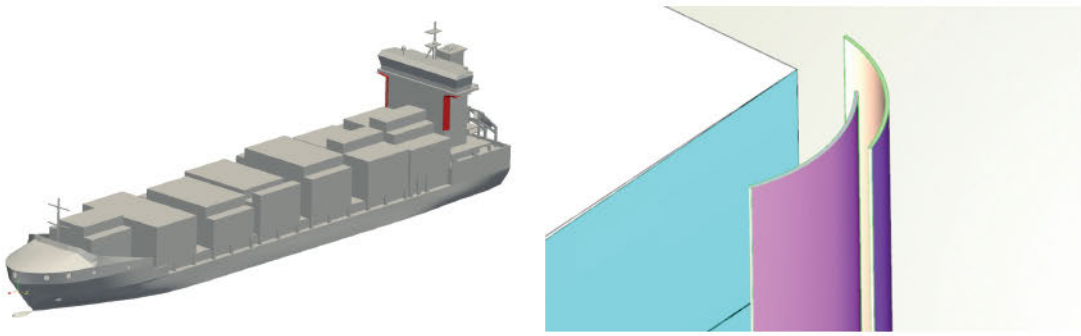


Fig. 2: "Left: Position of the deflector blade (red) on the front side of the deckhouse and detail of the 2 element blade section (right)"

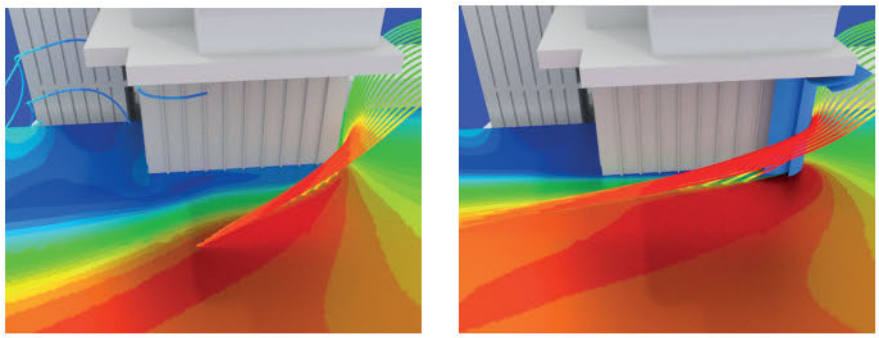


Fig. 3: "Improvement of corner flow on the front edge of the deckhouse using deflector blades"

reports listing speed, draft, wave heights and fuel consumption.

This type of vessel, typically carrying large deck cargo in varying configurations, does not lend itself easily to aerodynamic optimisation. However, initial analysis indicated that even for this type of configuration the appliance of deflector blades on the edges of the deckhouse superstructure would show a positive influence.

In the AERONAUT project a design study was performed to find optimal configurations for the deflector blade geometry. Based on a parametric CAD model generated in CAESES a large variety of different shapes, angles and positions for the blade geometry were investigated to arrive at an optimal configuration. Figure 2 shows the position of the deflector blade which covers the upper part of the deckhouse corner and blends into an extension underneath the bridge wing. Note the small size of the device compared to overall ship dimensions.

During the optimisation a large number of CFD predictions were performed to assess the influence of the deflector blades. Figure 3 indicates the flow around the deckhouse corner for the initial superstructure (left) and compares it with the flow pattern including deflector blades (right). The significant reduction of separated flow or 'dead air region' shown in blue is obvious in the right case with spoilers. This leads to a considerably reduced aerodynamic drag of the ship superstructure.

The reduction of total aerodynamic drag of the vessel, due to the application of the front spoilers, is about 10% as indicated on Figure 4 showing the comparison of time series analysis of the aero resistance. These findings were confirmed during wind tunnel experiments performed by TUHH in their in-house tunnel using the same geometry and container stacking.

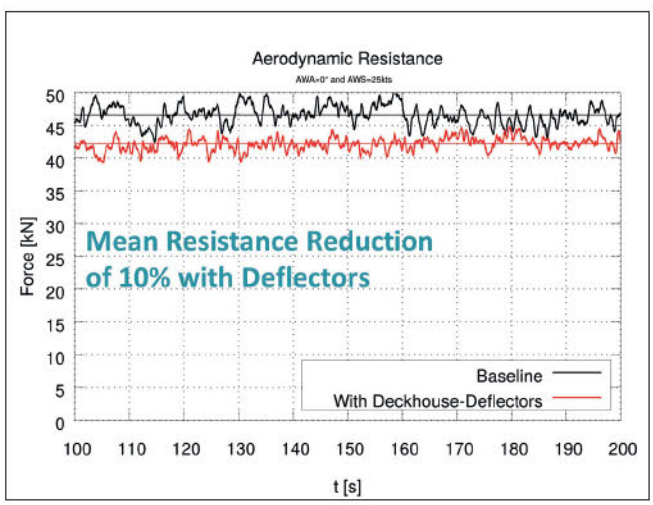


Fig. 4: Total aerodynamic resistance for the 1,000TEU container vessel with stowage

Full scale trials

In January 2020, the deflector blades were installed onboard of the test vessel *Pictor J* during a short yard visit and the ship continued operation soon after with a new charter. The installed starboard deflector is shown in the following figure.

Similar sets of noon reports as before were made available for the ship equipped with aerodynamic deflector blades during the first months of 2020. Unfortunately, the operational profile during this period does not match too well with the previous period so that a more direct comparison of conditions is difficult at the time of writing. Although the present results indicate a tendency of an improvement, more data are clearly needed to put this result on a firm basis.

In the meantime, data logging will continue and we hope to be able to install similar devices on more ships, preferably also tankers and bulk carriers, to increase the overall data set to be used for further

validation and the future assessment of the full aerodynamic potential of the re-fits. However, the positive effect of the aerodynamic deflector blades can be concluded and offers a further path to reduce overall resistance of ships and improve their energy efficiency.

Conclusions

Aerodynamic resistance can be considerable part of the "added resistance" for a large number of vessels and operational conditions. This holds specifically for slow (ship) speeds where wind forces are particularly important. AERONAUT developments show that the stratification of the aerodynamic flow over the superstructure of ships can reduce the resistance and spoilers and deflector blades bear a large potential. The container vessel investigated shows a reduction of the aerodynamic resistance of about 10%. The present long term full scale analysis however is hampered by too sparse data for an extended operational profile to prove this under real world conditions. More tests and data are needed to confirm numerical and experimental predictions. Other than for the present case of a container feeder vessel, the highest potential of aerodynamic drag reduction is expected for bulk-carriers and tankers, especially for operation in ballast condition where aerodynamic forces will contribute most to the overall resistance of a ship. *NA*

The AERONAUT project was funded by the German Ministry of Economic Affairs and Energy.

Fig. 5: Installation of starboard deflector blade on the test vessel *Pictor J*

Increase your CFD productivity to enable innovative solutions

Recent enhancements to Siemens' Simcenter STAR-CCM+ software simplify the setup of simulations and help avoid costly mistakes, explains Dr. Elspeth Mosedale

The recent enforced changes to working patterns have had significant effects for many. Delays to projects have been inevitable. In the marine industry, however, we have not seen a change to the longer-term goals for vessel design. Pressure in the commercial shipping market to increase vessel efficiency has not changed, and design projects for future vessels are still ongoing. But with increased economic uncertainty, design teams must make sure they are working as productively as possible and delivering innovative solutions that will help them differentiate from competitors.

Computational fluid dynamics (CFD) is now well-established as a performance prediction tool for ship design. In the new normal we find ourselves in, it has the added benefit of being digital and accessible from anywhere. With the right CFD tools, every aspect of vessel design and performance can be investigated virtually, well before the vessel goes into production. Teams can collaborate remotely as needed.

This article describes three new features within Simcenter STAR-CCM+, the CFD software from Siemens Digital Industries Software. These features are designed to embed best practices in every simulation, ensure reliability and repeatability and significantly reduce simulation times for marine cases. With these methods we can now rapidly consider hundreds or thousands of variations and trade-offs in designs, opening the way to innovation in both company working practices and ship design.

Figure 1: Setup via a template reduces set up time to minutes and ensures consistent set up of simulations

Templated set up reduces manual intervention

Setting up a standard CFD hull resistance calculation requires the same steps to be performed each time. We start with import and repair of CAD, defining mass properties and hydrostatics for the vessel. Then we can move on to building the mesh, making sure it is suitable for the physics we want to solve, for example wave heights and wakes, and suitably refined to capture boundary layer effects. After that we set the physics for the simulation, including boundary conditions, wave effects, turbulence model etc. Repeating this manually for each simulation is time consuming and can lead to errors in set up. Previously, we have reduced this manual set up by using scripting, but this has required significant effort to create and maintain scripts.

To simplify this process further, we developed a parameterised marine template within Simcenter STAR-CCM+. Template files are based on the simulation tree in Simcenter STAR-CCM+ and no external scripting language is required. This template automates geometry and model set up: the user needs only to import required geometry, then specify draft and speed. All other parameter definitions, for mesh and solution physics, are then set automatically via the solution operations programmed into the template.

Using this template reduces manual set up to a few minutes for any simulation. The templates are completely open and editable, which means they can be customised for any organisation's requirements and best practices. Experienced CFD users can define and maintain the templates, which can then be shared across the company. This ensures company best practices and workflows are used throughout, no matter who is running the cases. The Simcenter STAR-CCM+ standard marine template as shown here is freely available for use as a starting point.

Multi-Mesh Sequencing reduces time to solution convergence

Developing a complete flow field can take time on large and detailed meshes, as it takes many iterations for the solution to fully develop. To reduce this time, we have introduced a Multi-Mesh Sequencing (MMS) method within Simcenter STAR-CCM+. The simulation starts with an initial, coarse, mesh. As the flow field develops, MMS automatically refines the mesh, based on the developing flow field, and maps the solution on to the new grid. This refinement process repeats as needed

until a target mesh is reached. This final target mesh is defined by the user as part of the model set up and can be included in the template file.

This approach saves time by only using the detailed grid once the solution is almost converged. Using MMS does not require any scripts or coding. Instead, it is based on a method called "simulation operations" within the Simcenter STAR-CCM+ tree, so all the settings are embedded directly into the simulation file.

The MMS method has been extensively tested against our previous best practices for several different vessels, including the Lloyd's Register Blind CFD Benchmark case. For this case we analysed the resistance vs speed curve in calm water over four speeds. We compared the median of the workshop data to our previous best practice and our MMS method. Figure 3 shows there were hardly any noticeable changes in the results obtained, but we observed a simulation speed up of 2.2 times on average. Using the MMS method means we can now analyse twice as many designs in the same time as before.

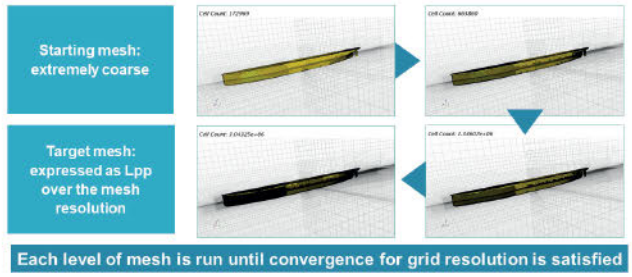


Figure 2: MMS automatically refines the mesh based on the flow field until a target mesh is met

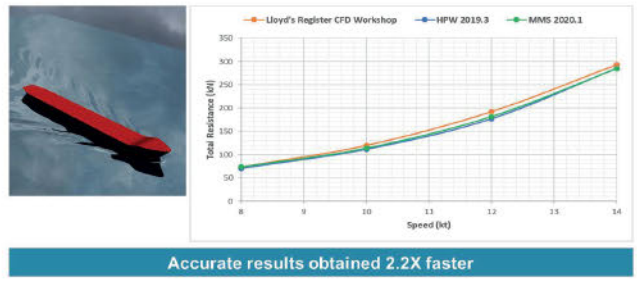


Figure 3: Results from MMS benchmark test using the Lloyd's Register *MV Regal*

Reduce mesh sizes with Adaptive Mesh Refinement

The best mesh at any point in time is one which has refinement in areas where you need it, and coarser mesh in other areas. When simulating moving objects such as wave fronts or vessel manoeuvring, specifying the required refinement before the simulation runs can mean excess refinement in areas where it is not always needed. To resolve this challenge, we have introduced Adaptive Mesh Refinement (AMR). This is a solver-based mesher which automatically refines and coarsens the mesh as the simulation is running. We have tested this for two marine-specific applications.

Figure 4 shows an example of AMR applied using free surface-based refinement on a simple prismatic hull. This method tracks the free surface and refines the mesh to ensure a sharp resolution of the air-water boundary. The technique employed predicts the rate and position of the free surface, so that refinement is also added ahead of the wave front. In this example, AMR ensured refinement of the spray as needed. It also intelligently found the spray root line on the hull and focused mesh refinement there. This significantly reduced numerical ventilation, while also reducing the overall mesh size. The AMR case ran 2.7 times faster than our previous benchmark.

Figure 5 shows another example, combining AMR with overset meshing for a moving vessel. Instead of refining all the mesh in the expected path of the vessel, only the overset mesh around the moving vessel needs to be refined. As the vessel moves, the surrounding mesh is automatically adapted to match the overset refinement. This resulted in three times fewer cells in the model and a three times speed up for the same simulation – again with no reduction in accuracy.

From one to hundreds of simulations

As a final step in testing the time savings for the methods described here, we measured time to perform a resistance sweep. For this test case we used the Siemens Multi Role Vessel (MRV) geometry and ran simulations for drafts between 5.5m and 7.5m, at increments of 0.5m, and speeds between 10 and 30 knots, with 2 knot increments. This equates to 55 CFD simulations. The simulations were driven via templating and included MMS.

User setup for this case was minimal: once the initial geometry was imported and verified, all other set up was driven from the parameterisation within the template. The sweeps were driven automatically using design manager, the design exploration interface within Simcenter STAR-CCM+. This has direct access to the template settings, so drives the parameter changes for each simulation. Again, no user scripting or intervention beyond initial setup was required. The single design manager job

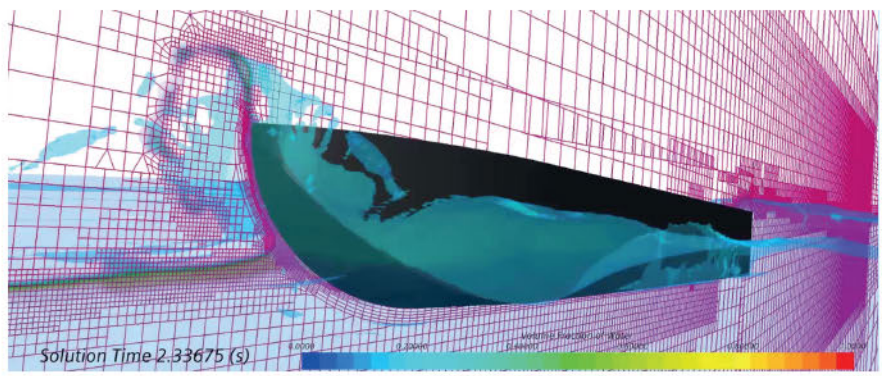


Figure 4: AMR based on free surface for a planing hull. The mesh automatically refines to capture spray

was submitted to a cloud-based cluster via Amazon Web Services, using 72 cpus per simulation. All runs were completed in less than 1 hour in total: average simulation time was between 15 and 30 minutes.

Conclusion

All combined, the methods described in this article create dramatic speed-up in CFD simulation times for even the most complex marine cases. The new template feature in Simcenter STAR-CCM+ automates simulation setup and ensures that all simulations are based on the same specified parameterisations. Multi-Mesh Sequencing and Adaptive Mesh Refinement significantly reduce mesh sizes, with no reduction in result quality. We have extensively tested these methods on a range of real-world examples, to ensure accuracy of solutions. In our test cases overall simulation times are reduced from days of computer time down to hours.

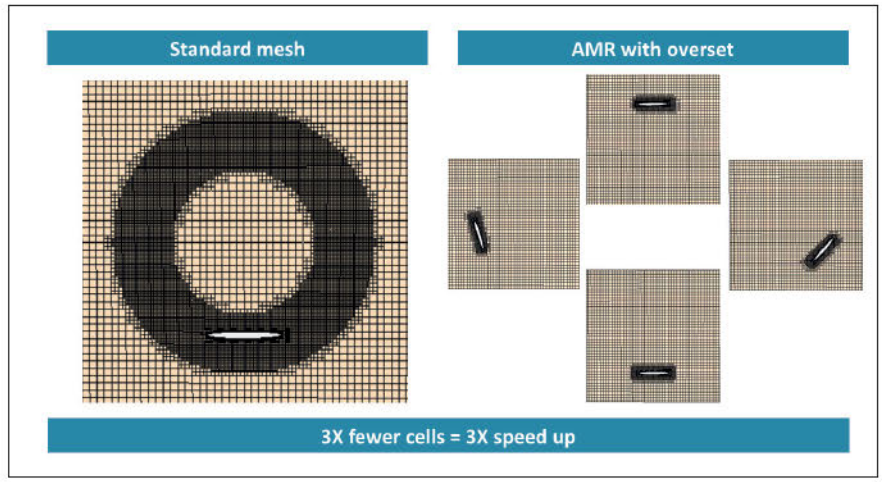


Figure 5: AMR with overset for moving vessels. The surrounding mesh automatically refines to match the overset mesh as the vessel moves

This increase in productivity gives freedom to investigate more designs or novel configurations, or to examine complex manoeuvres and other real-world scenarios. The tools described here are available for use today, increasing the potential to create innovative and efficient vessels in much shorter time frames. *NA*

When will CFD technology replace towing tanks?

Despite its advantages, IMO still only permits the use of CFD for design verification in special circumstances. But with the growing sophistication of simulation software could the tide be turning? Rodrigo Azcueta, of CFD consultants Cape Horn Engineering, believes so

Much has been said and written about technology transfer from elite sports to their associated wider industries, such as automotive cars benefiting from innovative processes used by Formula 1 motorsports teams. In the same way, the pinnacle of yacht racing sport, the America's Cup, has been using cutting-edge design tools to aid their performance for decades, specifically Computational Fluid Dynamics (CFD). We can consider how this specialist knowledge can be applied to commercial industries.

The advantages that the maritime industry can gain from CFD analysis is extensive, with far greater benefits than in other industries. Commercial shipping vessels in particular can benefit hugely by using this technology for significant reasons. This is due to the huge size of the ships, and the fact that they move at the interface between water and air. Planes are large as well, but they fly in one medium only.

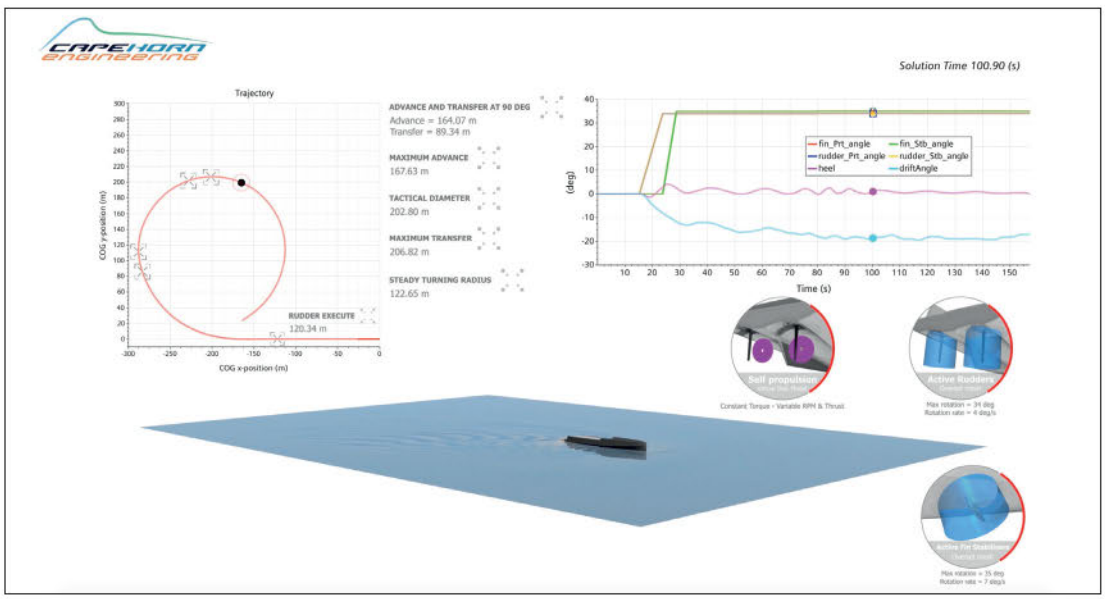
Cars, by comparison, are small and can fit inside a wind tunnel. But when it comes to ships, there are complicated physics involved and the actual forces acting on a real ship cannot be replicated on a model at scale in a towing tank. Due to this lack of force similarity, performance prediction from a towing tank is based on a lot of assumptions, empirical formulations and ultimately, experience. CFD on the other hand eliminates the main problem, as it can model the ship at full scale.

Historically, many designers have used more traditional technology, such as towing tank tests, for their final designs to make sure they meet their clients' requirements. "The shortcomings of towing tanks are most evident in the case of sailing yachts. Yachts create a large lateral force compared to the resistance and require special dynamometers. Moreover, yachts sail in a wide variety of conditions, they drift sideways, they heel over, they pitch and sail at many different speeds. Therefore, testing sailing yachts in towing tanks is much more difficult than testing motorboats. This is why racing sailing teams who want ultimate performance have embraced CFD technology long before the wider maritime industry has," explains Dr.-Ing. Rodrigo Azcueta, managing director of Cape Horn Engineering.

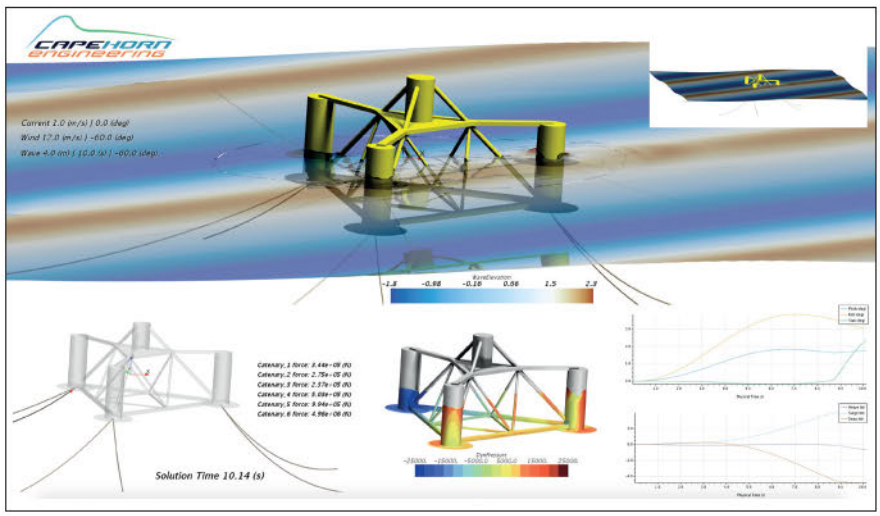
World class CFD specialist

Cape Horn Engineering is a UK based, best-in-class independent CFD consultancy with clients all over the world. Azcueta founded the company in 2007 with the vision of providing world-class expertise in CFD to support the design of racing yachts. He has been involved in four America's Cup campaigns. Yachts designed using Cape Horn Engineering technology and expertise have dominated the around-the-world Volvo Ocean Race for almost a decade, winning three times in a row.

Working for the America's Cup involves rigorous testing and validation to remain competitive at the highest level. It also requires access to large resources and working with a team of experts in many other disciplines. R&D and validation have



Turning circle manoeuvres simulation. Vessel with 6 degrees-of-freedom. Propulsion with Virtual Disk model at constant RPM during turning. Rudders and fins rotation using overset meshes. ITTC circle manoeuvre parameters (tactical diameter, advance and transfer, vessel speed and heel etc) obtained with simulation



Dynamic 6 DOF simulation for Offshore Wind Floating Platform under the effects of wind, current and waves. Platform only constrained by the catenary mooring system model

remained cornerstones in the development of Cape Horn Engineering's methodologies and experience. Azcueta, among a few other researchers, recognised the benefits of using CFD technology over physical testing many years ago and campaigned for using simulations only in the design of sailing yachts. Nowadays, all racing teams use CFD technology instead of towing tanks for the majority of their design efforts.

Cape Horn Engineering's technology and specialist expertise has not only evolved within this highly competitive environment but has also transferred across to other sectors such as the recreational and maritime industries. Their flow analyses have been proven time and again in a wide variety of other maritime applications including power boats, fully foiling and foil assisted high speed vessels, advanced and unconventional vessels, commercial cargo ships, and offshore platforms for renewable energy.

The best solution

When contemplating using CFD technology for commercial ship designs, the industry is still quite conservative. The natural preference is to rely on the 'tried and tested' experience of towing tanks for final designs to make sure that they meet client requirements. Taking the step to move forward with CFD technologies and adopting these tools to optimise designs will benefit all the stake holders involved in the maritime industry.

Azcueta comments: "Not only is CFD better suited than physical testing of sailing yacht designs, the benefits are also evident for large ships and offshore structures when considering manoeuvrability and seakeeping behaviour. For such analyses, large and complex tanks and wave basins are required and the costs of running such tests are considerable."

"Additionally, a good design process involves investigating the hull with its appendages and propellers simultaneously, as there is no isolated engineering component without an effect on the whole system. CFD allows us to perform calculations on the system as a whole, so the design process can be steered for performance, fuel efficiency, comfort and safety. For seakeeping and manoeuvring analysis, in the near future CFD will no doubt prove to be the best solution. It is not a matter of if but when."

The same conservative approach applies to the calculation and verification of Energy Efficiency Design Index (EEDI) introduced to newbuilds by the International Maritime Organization (IMO) with the goal of driving ship technologies to more energy-efficient ones over time. The main objectives of IMO's guidelines concerning the EEDI are to follow the best industry practices and ensure consistency. Yet, these guidelines are biased towards the use of model tank testing, with the use of CFD as a secondary option where results may be accepted under special circumstances.

However, tank testing uses scaled models even though some important issues related to the scaling of results will always remain and a unified approach to correction of the measured data has yet to be harmonised by the industry. According to the guidelines: "Numerical calculations may be accepted as equivalent to model propeller open water tests" and "Numerical calculations may be submitted to justify derivation of speed power curves, where only one parent hull form has been verified by towing tank tests, in order to evaluate the effect of additional hull features such as fore bulb variations, fins and hydrodynamic energy saving devices."

Unfortunately, CFD is not yet accepted as a mainstream way of calculating and verifying EEDI. But what if initiatives like the ongoing Joint Research Project (JoRes) (https://jores.net, see also *TNA*, November 2018), can change this? In this project, CFD simulations compete with model testing to determine which option is more accurate in predicting full-scale ship performance, aiming to demonstrate in 2021 that CFD predictions at full-scale are more accurate in predicting sea trial results than towing tank extrapolation from model-scale measurements. Will IMO change their guidelines and accept CFD as a mainstream way of assessing ship performance?

Azcueta is convinced this will eventually happen. The added value of CFD as a tool to improve ship design is unquestionable. But there are still some hurdles to overcome before it is officially accepted for performance and efficiency predictions. It is Azcueta's view that CFD can be directly validated with sea trials at full scale, and that there will be no more need for validation at model scale. He expects the results of JoRes will most probably confirm this assumption.

One significant barrier for the acceptance of CFD is ironically, its own success. The entry-level for new practitioners is fairly low due to good commercial software options offering out-of-the-box solutions for ship performance assessment. Inexperienced practitioners and naval architects without a CFD background can use these tools and produce results that at first glance look acceptable. However, validation, verification and experience are also fundamental for guaranteeing accurate consistent predictions and cannot be underestimated.

Azcueta continues: "Many CFD companies and institutions have been involved in CFD validation for ships

of all sizes and types for decades, using model-scale tests for comparison. That chapter is now to be closed. The budgets for acquiring measurement data during sea trials, that can be used for CFD validation, are very similar to the costs of running tank testing for the same vessel, according to the budgeting of the JoRes project. So, why still use tank test models for validation?

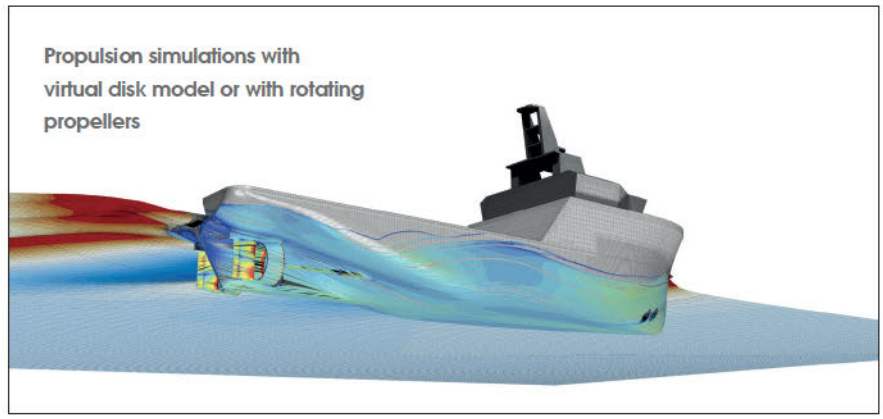
"CFD companies do not have the large overhead costs that towing tanks have for operating a tank, therefore do not need to justify those overheads by selling a less efficient service in the form of hours in the tank. Such companies are in a good position to compete with towing tanks. What CFD companies and institutions may need, is to pass a level of certification, such as ISO 9001:2015 for quality management of services, and to work closer to classification societies, in order to be officially recognised as able to calculate and verify EEDIs and sea trial performance."

During sea trials, not only the attainable speed of the vessel is tested and certified, but also manoeuvrability and directional stability. Simulation is becoming the tool of choice for performing standard manoeuvres and CFD experts are experiencing an increase in enquiries from customers interested in manoeuvrability at an early design stage. Similarly, there is a higher demand for predictions in seakeeping, accelerations in waves, levels of comfort and likelihood of seasickness. Here again, CFD offers advantages that tank testing does not. To confidently determine seaworthiness (manoeuvres and motions in waves) at the design stage will be an important aspect for the future development of autonomous vessels.

Considering in-house CFD?

Many larger shipyards have built up their own CFD capabilities using an array of different software systems, but this may not necessarily prove the best strategy for small and medium size design companies. Should these design offices also choose an in-house option, or should they outsource to an external CFD service provider? What are the other considerations apart from cost?

There are several main factors to consider when deciding whether to establish an in-house CFD facility or to engage an outside service provider. Initially, one might think that having an in-house CFD capability is safer in terms of confidentiality, and faster in terms of the reaction time. However, building up an in-house CFD facility is not that straightforward. It is expensive with regard to hardware, software and expertise, and challenging to keep abreast of rapidly developing CFD technology. Software vendors often tend to present clients with an optimistic view on staying current with new developments, but the rate and complexity of developments mean this may prove not to be the case and can lead to disappointment and delays along the way.



Another factor to consider is that there are not many CFD experts available, so design offices may have to employ more junior practitioners. Their lack of experience may result in poor quality, delayed delivery and thus increased costs. And finally, the required resources; people, computers and software licenses may not be used 100% of the time, which adds extra cost to the design process. Conversely, if the person in charge or running simulations is not entirely dedicated to this complex task all year round, they may never get the expertise required to become an expert.

Choosing the right CFD service provider

So, at what point is it advisable to outsource CFD analysis to an independent provider who you can trust? A dedicated CFD specialist will have far greater resources allowing the delivery of better analysis in a shorter time and at a lower cost. On a small in-house computer, a project may take weeks to complete compared to just days by a dedicated CFD company with access to high performance computing clusters. This is very important for design managers who often expect results to be delivered the day before they give the green light to a project! In such a situation, where timing is crucial, a trusted external provider can deliver confidential and accurate results with the guarantee that the analysis is performed according to best practices obtained through years of experimentation and tool validation.

The question remains how clients can tell a high quality CFD service provider from a not-so-good one. Today, there are many new so-called CFD experts who claim to predict performance within 1% precision. The main concern with choosing a CFD provider is that it has now become very easy to produce some sort of results and nice flow visualisations, which can look impressive. The CFD provider should have the relevant expertise, discipline, experience and most accurate software to run simulations and analysis to the exacting standards required. For this reason and to ensure that the best possible results are delivered, it is crucial to choose a CFD provider carefully, based on resources and expertise.

A good indication are the tools that are being used, the computing resources and their track record in past projects. Cape Horn Engineering makes no compromise on software quality. In Azcueta's view, they use the best CFD package on the market, Star-CCM+ from Siemens PLM. The associations with products of the same family started 25 years ago when Azcueta pioneered simulations with free surface using the code COMET, one of the predecessors of Star-CCM+, and has since contributed to the further development of the software capabilities. *NA*

How to speed up CFD-based optimisations for better products

Simulation-driven design leads to excellent products but still demands skill, time and resources. Stefan Harries and Hedi Böttcher, of Friendship Systems AG, discuss state-of-the-art simulation-driven design in the maritime industry and potential solutions for realising faster turn-around times, including a method for a massive reduction of parameters

Today's state-of-the-art in simulation-driven design (SDD) is to build a parametric model and connect the geometry to a flow simulation and then to repeat the generation of variants and their assessments as often as the resources allow, see Harries (2014). The simulations yield, after quite a bit of number-crunching, the flow field for each variant from which objective functions (as key performance indicators) are derived, say resistance, pressure drop, flow homogeneity, wake fraction, etc.

In order to come up with new variants automatically without any need of manual input, a meaningful strategy is employed. Typical strategies are systematic parameter studies, Design-of-Experiment (DoE) for exploration, deterministic search algorithms for (local) exploitation and global methods combining both exploration and exploitation, Harries et al. (2019).

The standard process of SDD comprises the following steps as illustrated in Figure 1:

- Generate a geometry for given CAD variables;
- Pre-process the geometry for input to (external) simulation(s) (typically for a CFD analysis a watertight triangulation would be needed);
- Trigger the simulation(s) in batch-mode by providing the necessary input file(s), including the geometry of the current variant;
- Read data from the simulation tool(s) (such as flow fields and integral values like resistance) by parsing the output file(s);
- Post-process the available data (for instance, determine objective(s) and constraint(s) and visualise variants);
- Assess all variants available so far and have the optimisation strategy decide on changes to the free variables;
- Start a new chain of events with new values of the free variables unless the resources are spent and/or good designs have been found.

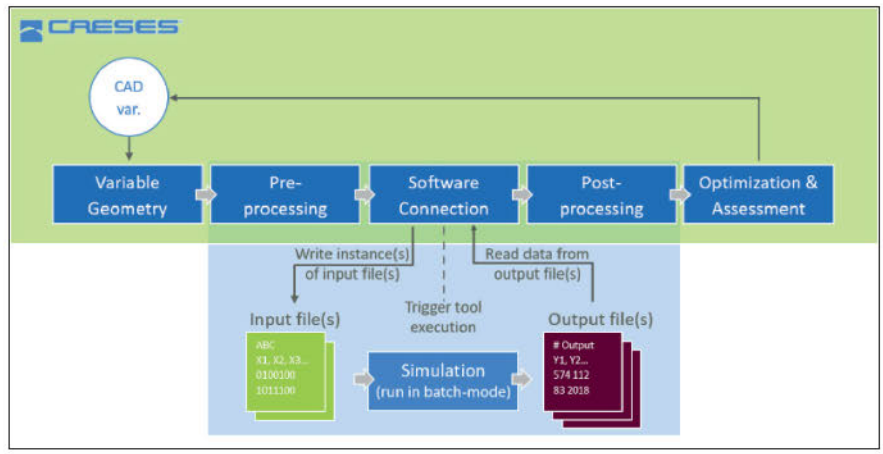


Figure 1 - Standard simulation-driven design process realised with CAESES

CAESES by Friendship Systems AG, Germany, is a Process Integration and Design Optimisation (PIDO) environment with built-in CAD functionality. The focus is on variable robust geometry, as needed for ship hulls, propellers, ducts and rudders, but also for intake ports, impellers, volutes and manifolds for turbomachinery. CAESES allows the coupling of any external tool that can be run in batch mode. Codes that are typically triggered and controlled via CAESES for design and optimisation are Computational Fluid Dynamics (CFD) codes like CFX, Converge CFD, FINE/Turbo, Flow-3D, Simerics MP and STAR-CCM+ along with dedicated tools for naval architects such as FINE/Marine, SHIPFLOW, ShipX and v-Shallo. The idea is to investigate large numbers of design variants from which to select the best solution, for instance, the ship with the highest energy efficiency at a range of speeds fulfilling a specified transport task.

The true bottleneck of every design task is that the design space scales up very quickly with the number of free variables (DoF of the system). A first guess for the minimum number of variants to be studied is the square of the DoF as explained in Bergmann et al. (2018). If the objective function is well behaved with regard to the free variables, a lower number of variants may suffice. This, however, is difficult to judge a priori.

The free variables are typically those parameters of the model that are under the control of the design team and that shall be deliberately changed within certain bounds. Consequently, parametric modelling is – more than anything else – an attempt at intelligently reducing design spaces for specific design tasks as much as possible. Any free variable that can be omitted, decreasing the dimensionality of

the design space, potentially saves a lot of time and costs.

Therefore, instead of allowing complete flexibility the design teams typically take into account every available piece of information from experience and constraints known from production, operation, company strategy, market acceptance, etc. Hence, all good parametric models stem from a conscious choice of restriction.

One approach to speed-up simulation-driven design tasks by means of a parameter reduction method will be shown in the following. Another approach of reducing the number of simulation runs is to solve the so-called adjoint equations. Adjoint equations (or adjoints) are differential equations derived from their primal equations in order to determine gradient values with respect to a chosen quantity, i.e. the objective to be optimised. In fluid dynamics this may be resistance, pressure drop etc. and the primal equations would then be the RANS equations.

Massive parameter reduction to speed up optimisation

As discussed in Harries et al. (2019), the number of free variables by which a design task is described plays a decisive role in simulation-driven design. The higher a system's degree-of-freedom the more simulations are usually needed to understand the system and to find improved designs. Not surprisingly, faster turn-around times come from intelligently reducing the DoF and, as a consequence, cutting down the necessary number of simulation runs.

A traditional CAD model may easily feature hundreds, if not thousands, of controlling entities such as the vertices of a large set of B-spline surfaces. In advanced parametric modelling these entities are not individually located in space but are determined in a task-specific and highly concerted way. Currently, this is the most important and most widely spread solution to reducing design spaces. The number of free variables of a well-made parametric model is typically around 10 to 20, occasionally goes up to 50 and may exceptionally reach 100. More free variables are practically unaffordable for most design teams since relevant simulations simply take too much time even if sufficient computer resources are at hand.

A very promising approach of reducing the DoF is to introduce so-called principal parameters by means of a principal component analysis (PCA) as will be shown in the following. From the preliminary experience gathered so far, see Pellegrini et al. (2018) and Bergmann et al. (2018), it seems that the design space of principal parameters can be as small as five parameters while still having enough freedom (variability) to control the shape.

Dimensionality reduction method and associated SDD process

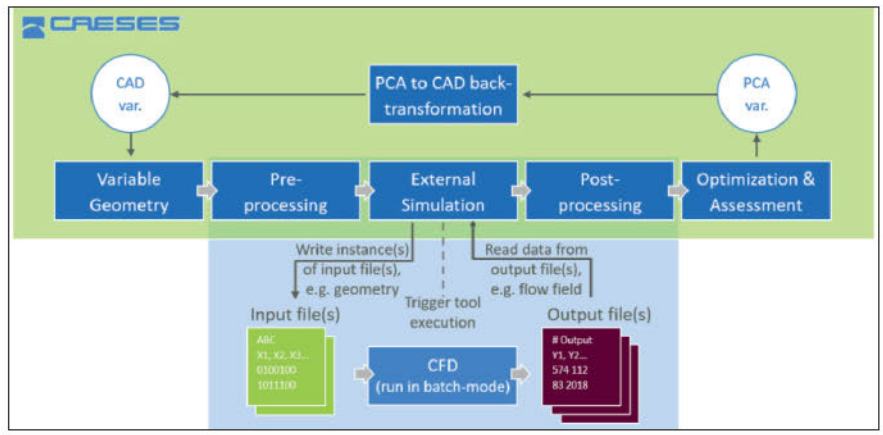
In the context of hydrodynamic optimisation the dimensionality reduction method (also known as Karhunen-Loève Expansion (KLE), or Principal Component Analysis (PCA)) was first proposed by Diez et al. (2015). A large sample of shapes is analysed with regard to an orthonormal basis that minimises the error of deviations from the mean shape. To this end, in simulation-driven design the CAD geometry is discretised by a structured set of points in three-dimensional space. A DoE is undertaken to create the sample for the principal component analysis. Typically, several thousands of variants would be generated. Since no CFD simulations need to take place at this stage, the sample is pretty fast to realise even for complex models with several seconds of update time per variant.

While the points are topologically the same, they naturally differ in their coordinates due to the variations in the values of the free variables of the CAD model, i.e. the CAD variables. The coordinates are interpreted as statistically uncorrelated data and a shape modification covariance matrix centred about the mean is built from them. The Eigenvectors of this covariance matrix then form the basis of a new space, the so-called principal component space, while the associated Eigenvalues represent the variance retained.

A considerably lower set of principal parameters, i.e. coordinate directions of the principal component space, is chosen, deliberately sacrificing some of the CAD model's variability. The geometric variability of the new PCA model is determined as the sum of the Eigenvalues associated with each Eigenvector divided by the total geometric variance of the original CAD model. A variability of 100% would mean that all variants considered within the sample can be exactly reproduced. Principal parameters are ordered according to their importance. Interestingly, quite often 95% of the variability is already attained with just a few of the most influential principal parameters. This then enables a design team to work within a massively reduced design space as can be appreciated from Table I.

The PCA based SDD process is illustrated in Figure 2. Different to the standard process shown in Figure 1, the optimisation strategy addresses the CAD variables indirectly by actually modifying the principal parameters. These now serve as the free variables addressed by an optimisation algorithm while the former free variables in the CAD space have

Figure 2 - PCA based SDD process as realised with CAESES



become the dependent variables needed to realise a suitable instance of the shape. The associated values of the CAD variables need then to be determined through a back-transformation.

Finally, it should be noted that the PCA approach as discussed here does not take into account any relationship between geometry and flow field yet. This will only be established by means of the flow optimisation to follow. Potentially, this implies a certain risk, namely that small geometric changes which could have a large impact on the flow are not duly represented by the principal parameters selected before cutoff.

Illustrating example

The massive parameter reduction approach will be shown on a complex fully-parametric turbocharger compressor for a marine engine, shown in Figure 3. The rotating impeller consists of 11 main blades while the vaned stator comprises 19 diffuser vanes. No splitter blades are included thereby all of the blades are full blades. The main blade shape is defined by a total number of 16 design variables, allowing the modification of the camber surface and the leading edge geometry.

For the shape definition of the diffuser vane a total number of 10 design variables are used. The impeller operates at a rotational speed of 37,000rpm and has a diameter of 195mm. It should be mentioned that the original highly complex fully-parametric model of the centrifugal compressor used for investigation comprises more than 60 design variables. Using all of the variables would lead to an immensely high computational effort.

Therefore, a still high dimensional design space, comprising 26 design variables is chosen as a subset, to prove the method of dimensionality reduction and keep the computational effort within reasonable limits. A single main blade and diffuser vane of the compressor are looked at for the dimensionality reduction approach. For the sample creation in order to perform the dimensionality reduction the main blade and diffuser vane are discretised, as shown in Figure 4. The aim of the optimisation task is to maximise the compressor's efficiency. FINE/Turbo is used for the CFD analysis.

		Cuboid	HVAC duct	RoPAX ferry	SWATH	Compressor component
Number of free variables of the original CAD model (DoF)		3	14	14	27	26
Number of Sobol variants used for PCA (sample)		100	1000	3000	3000	3000
Variability reached with 1st principal parameter	1	35.8 %	83.8 %	92.4 %	72 %	50.6 %
Variability reached with 1st and 2st principal parameters	2	69.3 %	92.1 %	98.3 %	86 %	81.5 %
Variability reached with the first three principal parameters	3	100.0 %	95.8%	99.3 %	94 %	93.6 %
Variability reached with the first four principal parameters	4	–	97.4 %	99.8 %	96 %	95.6 %
Variability reached with the first five principal parameters	5	–	98.5%	99.9 %	98 %	97.1 %
Variability reached with the first 10 principal parameters	10	–	99.7 %	99.9 %	99 %	99.6%
Number of principal parameters needed to reach more than 95 % variability		3	3	2	4	4

Table I. Variability reached with principal parameters for various shapes (adapted from Bergmann et al. (2018))

Principal Parameter based optimisation of complex parametric compressor component

Taking a closer look at the geometric variance that is retained by each new principal component can support the decision on how many principal parameters should be included in the optimisation task (see Figure 5).

The plot depicts a fast decrease of the variance captured by each individual principal parameter. Therefore it may be sufficient to use only the first few principal components for the optimisation task. The first four principal components already retain 95% of the total geometric variance. The first six principal parameters already cover more than 98% of the geometric variability in comparison to the original CAD model.

Design velocities are a functionality in CAESES to visually inspect parametric models and to understand where and how

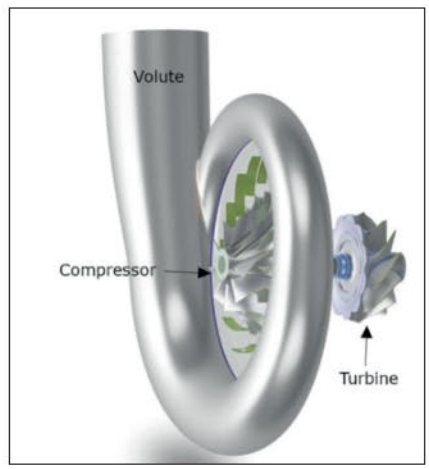


Figure 3 - Fully-parametric turbocharger model in CAESES

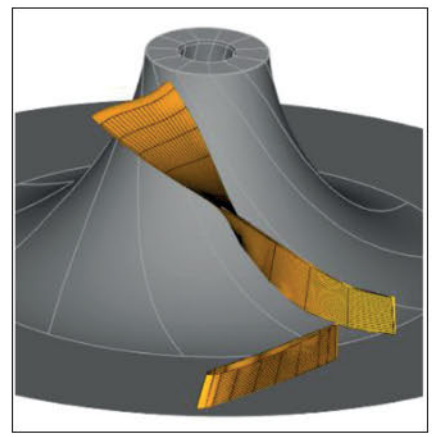


Figure 4 - Compressor main blade and diffuser vane with discretisation points used for the PCA

strongly each variable influences the shape. For an illustration of how each principal parameter influences the shape of the main blade and diffuser see Figure 6. The design velocities are depicted as vectors, showing the modification of each discretisation point on the blade surfaces.

Results and conclusion

With FINE/Turbo being connected to CAESES all optimisations, both in CAD and in PCA space, were undertaken within CAESES directly, using the built-in strategies such as a Sobol (for a DoE) and a TSearch optimisation (for deterministic search) as shown in Figure 7. The best design found in CAD space, using the full set of 26 design variables showed an efficiency of 88% after 123 variant evaluations, the baseline's efficiency being 84.5%. A similar improvement by 3.5 percentage points in efficiency could be found after only 79 design evaluations using the massive parameter reduction approach by means of a PCA and a combination of a Sobol with 4 followed by a TSearch with 6 principal components. Focusing on the direct search optimisation based on 4 principal parameters it is quite interesting to observe the fast improvement of efficiency by 2.6 percentage points after as little as 21 design evaluations. Though it also shows the limits of further design improvements that lie beyond the range of shape modification possibilities when only using 4 principal components.

As briefly shown, working with design spaces that comprise less degrees of freedom is a great benefit. Many resource intensive, time consuming and costly simulation runs can be spared, by working with less dimensions. The greatest advantage is the substantial design space reduction from a high dimensional space consisting of more than 25 dimensions to a few dimensions of four to six without losing much variability of the model. The former high dimensional space can afterwards be covered by a handful of new principal parameters, while deliberately sacrificing only a small portion of the CAD models geometric variability. CFD based optimisations of complex parametric models can be accelerated to create better products even faster.

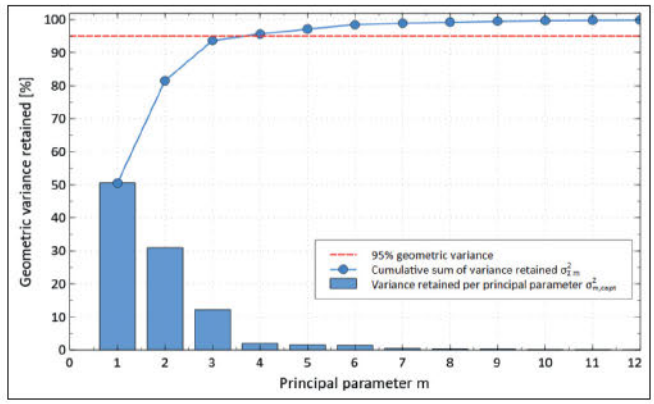


Figure 5 - Geometric variance captured by each principal parameter and cumulative sum of the variances captured

For more detailed insights, please see Bergmann et al. (2018), Böttcher (2020) and Harries et al. (2019). *NA*

Acknowledgement

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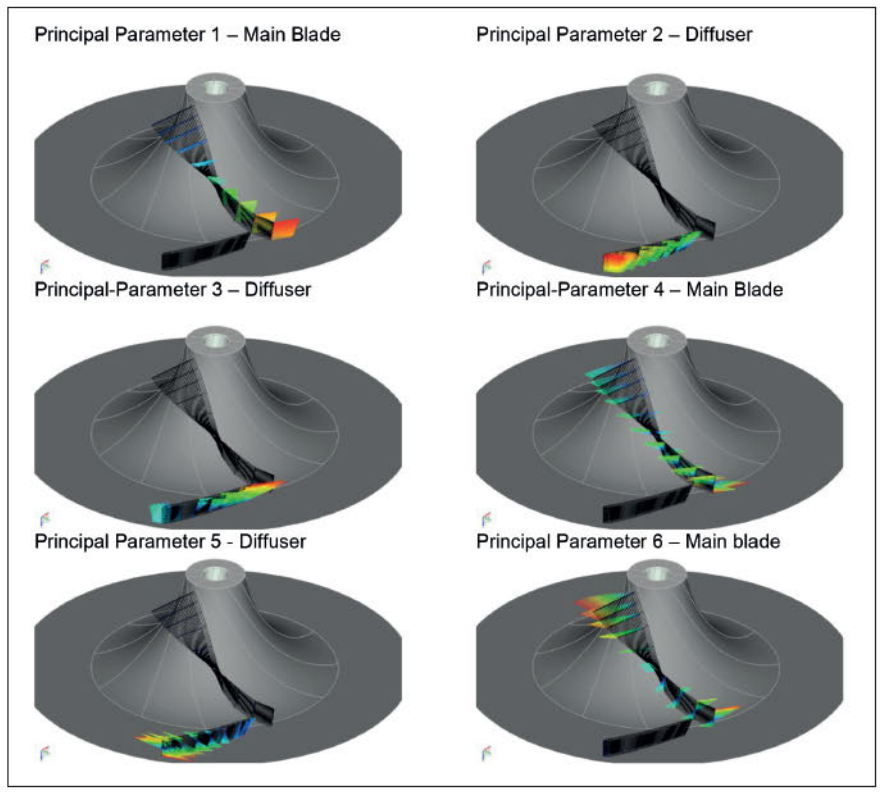

Figure 6 - Influence of the first six principal parameters on main blade or diffuser shape

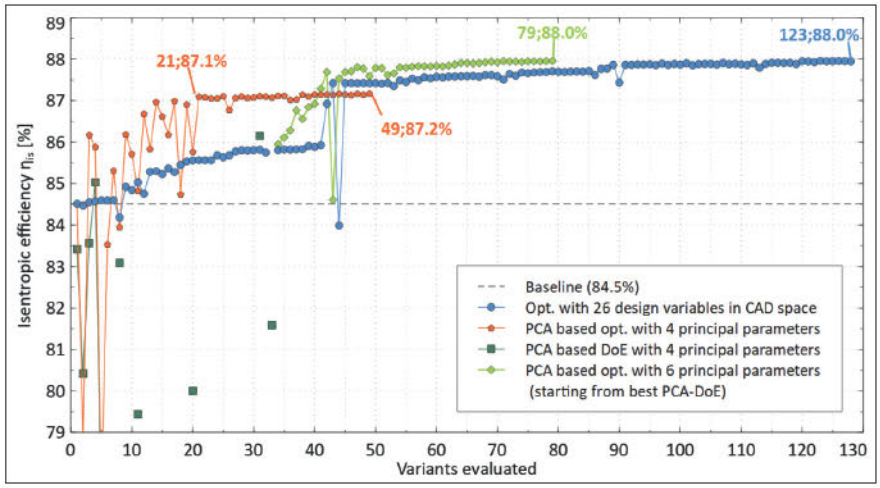

Figure 7 - Optimisation history

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The transition to biocide free coatings

Carl Barnes, general manager at coating consultants Safinah Group, considers the evolution of antifouling technologies and how the latest solutions really perform

Controlling fouling on immersed surfaces has been a requirement since ships have been used as a means of transport. Historically, 'biocides' such as mercury, arsenic, lead, pitch and copper were used to prevent fouling of ship hulls. The use of copper plating of hulls was first suggested in 1708 by Charles Perry, however it was rejected by the Navy on the grounds of high cost and perceived maintenance difficulties.

In 1761, the frigate HMS *Alarm* was the first ship to have its entire bottom coppered, in response to the terrible condition in which it returned from service in the West Indies. At the battle of Trafalgar, October 1805, the British fleet used copper cladding, which controlled fouling and gave them more manoeuvrability than their French counterparts. Copper plating continued to remain the standard method of protecting a ship's underwater hull until the advent of steel ships and antifouling paints.

From about 1867 antifouling paints have used rosin which is a natural acidic material obtained by tapping living trees, predominantly across Asia and South America, combined with biocides. When immersed in alkaline seawater there is a slow dissolution of the rosin, similar to the way a bar of soap disintegrates when left in water, releasing the biocides to deter fouling. The dissolution gradually slows over time due to the formation of insoluble materials at the coating surface. Modern day versions are termed Controlled Depletion Polymers (CDP) and typically have an effective lifetime of up to 36 months.

1974: a watershed moment

In the early 1970's two significant step changes in fouling control occurred:

- Tributyltin (TBT) Self-Polishing Copolymers (SPC) were developed;
- The discovery that silicone elastomers could be used to prevent fouling – Foul Release Coatings (FRC).

TBT became the 'winner' at the time but, interestingly, both technologies were discovered by accident. Tributyl tin oxide (TBTO) was a well-known but expensive biocide and the challenge was to bind TBTO to an acrylic polymer to make paints last longer and be more cost effective.

The first ship trials using this system were deemed a disaster, with shipowners complaining of heavy fouling after only six months because almost all the paint had disappeared except in the middle of the shell plating. It was realised that the remaining paint in these 'valleys' made the hull smoother, and the term 'polishing' was used to describe this effect.

Laboratory work continued to find a way to control the polishing rate and in 1974 the first SPC was launched.

In a similar development project, rubber tiles impregnated with biocides were glued onto a base plate using silicone sealant. The biocide impregnation failed but the silicone sealant remained clean and FRC were born.

TBT SPCs went on to become the industry standard as they were easy to apply, relatively low cost, delivered excellent performance across all ships and trades and allowed commercial shipping to extend docking cycles to five years for the first time.

Negative effects on non-target organisms ultimately led to the ban of TBT coatings under the IMO International Convention on the Control of Harmful Anti-fouling Systems in Ships (AFS Convention) in 2008 and SPC technology based on Silyl Acrylate or Metal (Copper or Zinc) Acrylate replaced TBT.

During the 1990s, FRC also became a commercial reality and today there are generally two main choices for fouling control. Biocidal antifoulings based on SPC, CDP and blends of these technologies or FRC are also available.

Regulatory pressure to reduce biocides

Currently there are only a handful of biocides available that can be used in biocidal antifoulings, which still account for around 90% of the fouling control market. There is however increasing regulatory pressure to reduce the use of biocides.

The European Union (EU) has the most stringent requirements for biocidal coatings, via the Biocidal Products Regulation (BPR) which governs the review and approval of biocides. The next review is due to take place in 2025 and it is expected that some biocides will not gain re-approval.

Under the BPR the biocide Zinc Pyrithione (ZPT) is still under review, should ZPT not gain approval then scrutiny would fall on Copper Pyrithione (CPT), used in approximately half the antifouling products available. Removal of CPT would see the fouling control market hit with a new wave of unproven technologies. Furthermore, signatories to the AFS Convention agreed to banning the biocide Cybutryne (Irgarol) from 2021. In Asia regulations for biocides are typically introduced with limited notice, therefore the timescales for coating suppliers to react, and for the development and testing of new technologies, is limited.

Due to the overall cost and registration timescales, few new biocides have been commercialised. Those which have include encapsulated DCOIT (Sea-Nine Ultra), Medetomidine (Selektope) and Tralopyril (Econea). These biocides are typically copper free or use encapsulation technology to control the release of the biocide to maximise performance and reduce the risk to humans and the environment.

Biocide free technology

Due to increasing concerns over the accumulation of heavy metals in the environment, considerable research has gone into the development of effective copper-free antifouling's (see *TNA*, June 2020). The next step on this journey is biocide free, this technology has existed for some time and innovations in this area continue, however the choice for shipowners is limited. Commercially available options include:

Foul release coatings (FRC):
Biocide free FRC are based on a silicone matrix that either prevents fouling attachment or facilitates removal through the action of water while the ship sails. Whilst

FRC have shown excellent performance on some vessel types / trades they are generally more suitable for higher activity, faster ships. Although recently developed products claim improved performance at lower speeds, they are currently not an option for all vessel trades. Other issues include:

- The application process can be challenging due to the need for masking to protect surrounding areas from contamination and the need for dedicated application equipment, adding time and cost to the operation. FRC are also sensitive to temperature and humidity during application;
- FRC have poor anti-abrasion properties and are easily damaged during poorly managed underwater cleans, via canal transits, entering / exiting ports and are unsuitable for ships trading in ice;
- Unlike biocidal antifoulings, the number of times FRC can be re-coated at drydock is limited, before full blasting of the hull is required.

Biocide free SPC:
A relatively new and promising development has seen the launch of a biocide free SPC, based on a polymeric material designed to prevent blood clots during the creation of artificial hearts and blood vessels. The technology is claimed to continuously self-polish and smooth, exposing active micro-domain structures to prevent fouling build up.

Hard coatings:
Based on epoxy technology and biocide free, hard coatings will foul relatively quickly. However, they are designed to be subjected to regular in-water cleaning without damaging the integrity of the coating. These coatings claim to offer good abrasion resistance and are suitable for trading in ice. However, due to regional and local restrictions, planning and executing regular in-water cleaning operations can be challenging for ships not operating on a fixed route.

Other biocide-free innovations:
Include ultrasonic technologies, Ultra Violet (UV) lights and hull aeration among others. Despite promising results in some cases, these innovations are some way from commercialisation with challenges related to scaleup, maintenance and additional power requirements. In addition, some of these technologies may not yet be suitable for the entire underwater hull.

Masking of surrounding areas during FRC application

Biocide free fouling control future

Shipowners are under increasing pressure to control costs and to comply with emissions to air and sea. Fouling control coatings are acknowledged to make a significant contribution to the operational efficiency of marine vessels, if the correct product is selected for the appropriate ship and trade. However, based on the analysis of our (Safinah Group) extensive dataset of vessel returns, the evidence to date implies that approximately 50% of ships return to dry dock with more than 20% fouling coverage on the underwater hull. This suggests that either the current fouling control coatings are not performing as planned or the coatings specified are not suitable for how the ship eventually traded.

The biocides available to the paint formulator today have come a long way in terms of impact on the environment compared to TBT and historical biocides. However, there will continue to be regulatory pressure for all fouling control to be biocide free.

Whilst proven biocide free options are available, due to the complexity of vessel types, trades and fouling challenges these options may not fit all. Biocidal antifouling coatings are currently still the best option for low activity, extended static periods, coastal trades and fitting out protection at newbuild. In the short term a combination of hull cleaning with a biocide free option, selected based on performance data, could be a way forward but can pose different challenges to the environment.

With the current technologies struggling to match actual vessel operations and future changes in legislation driving coating companies to introduce new technologies, the need for independent data on product performance and functional specifications based on vessel trades is critical in specifying biocide free fouling control products.

Safinah Group's technical services team project managed the application of fouling control technologies available on the market and have a comprehensive database of the performance of these products upon return to drydock.

Ultimately the introduction of new innovations for fouling control is costly, time consuming and shipowners are reluctant to use unproven technology. Collaboration by all industry bodies not just the coating suppliers is needed to test new biocide free technology to ensure the next watershed moment in fouling control is realised. *NA*

Safinah Group attendance at dry dock

Taking Panama into the future

Naval architect Noriel Arauz discusses the challenge of leading the technological transformation of the world's oldest and largest ship registry

The digital age is causing a deep transformation in society. Organisations are compelled to enter a process of change that drives them into resetting their productive processes and the functional areas on which they are developing. The digital world has multiplied exponentially across everyday life and interconnection is the basis of the whole process. The maritime sector and especially the ship registry are no strangers to this new reality: the registries must confront the difficult decisions involved in order to adapt or risk disappearing.

These are the main reasons that leading naval architect, Noriel Arauz, accepted the challenge of leading the technological transformation of the Panama Maritime Authority (AMP), as administrator of its ship registry and minister for Panama's maritime affairs.

With more than 100 years leading the business and more than 8,000 registered ships, Panama has been a frontrunner in ship flagging services since the early 1900's. Panama offers many assets to the world maritime industry, but for Arauz, these are summed up on a single phrase: the backup of an entire country supporting our shipowners and seafarers.

Noriel Arauz was appointed AMP administrator and Panama's minister of maritime affairs in July last year

Constant vigilance

Operating under the auspices of the Panamanian government, which makes it an organisation with all the diplomatic, politic and economic tools required to guarantee clients that their ships and ship mortgages are protected at all times. It has been so through the years, regardless of conflicts, wars, economic crisis, pandemics and other kinds of events. Panama has neither suspended its maritime services, nor abandoned its seafarers or its ships at any time.

These are the keys to the sustainability of the flagging business in Panama. Nevertheless, technology requires us to rethink our strategies, policies and routine methods. Consequently, the registry continues to focus on new products, commercial opportunities, processes, financial strategies and, above all else, on being closer to its clients.

Team effort

The complexity of technological transformation relies fundamentally on the people and the organisational culture, since the challenge of transformation is of very little worth if the professionals – the main characters of this scenario – are not prepared or willing to get the work done.

Therefore, Arauz considers that the keystone of success of this great project is teamwork. That means a strong emphasis on continuous training, identifying and enhancing the expertise of the AMP staff, and applying a collaborative training plan based on new technology, which is attractive, interactive and easy to use. All these factors are part of the strategies under development as a means to building a team, that under good leadership, aims to innovate and transform the registry´s way of doing business.

Looking ahead

The maritime industry has hundreds of years of experience and its solid foundations should help it to move forward for many years to come. Nevertheless, Arauz thinks the industry needs to get behind new policies to ensure its livelihood, particularly with regard to environmental protection; the pursuit of more efficient machinery and technologies; and the safety and preservation of life at sea.

To realise these goals at a time of uncertainty, not to mention intense competition, and persuade others of the need to accept a new way of doing things, requires techniques and attitudes that Arauz has developed across more the 20 years in the industry. During that time he has had the opportunity to collaborate in most of the segments of the maritime business.

He believes that his experience and vision for the future of maritime, along with solid support and collaboration, can take AMP forward as a pioneer and role model for other flag registries across the world. *NA*

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