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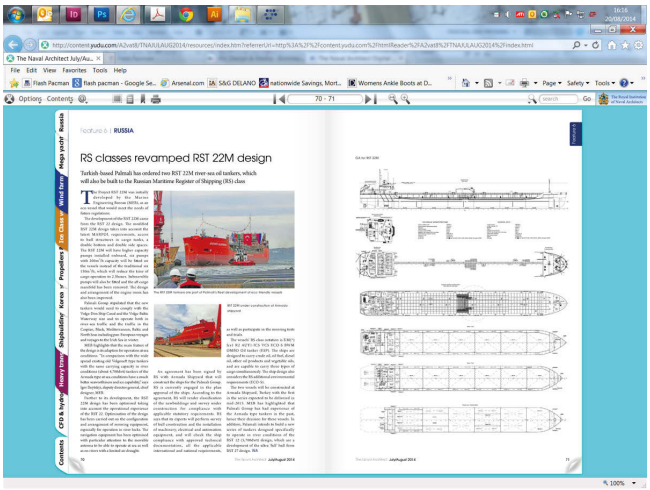

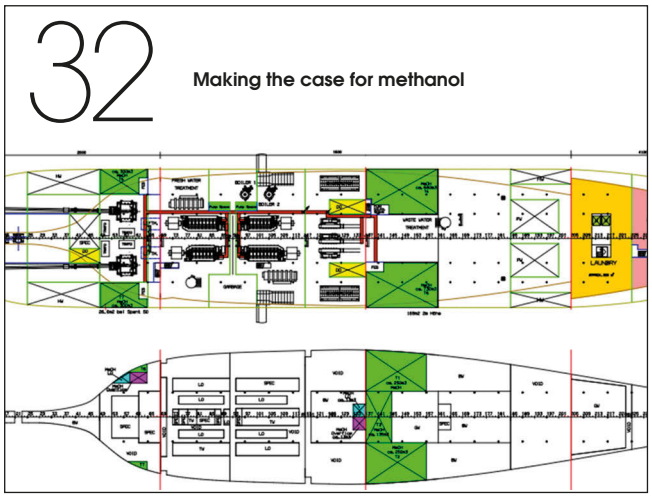

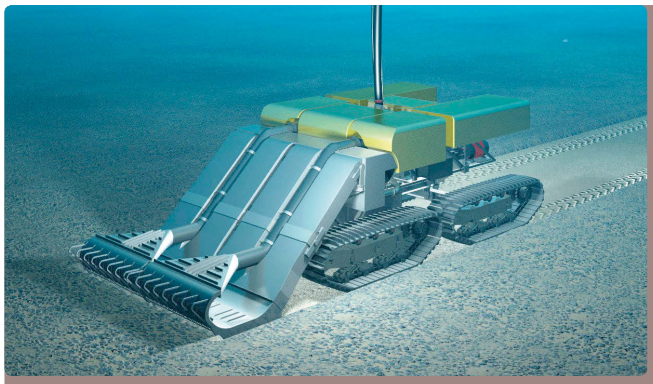

Where the blue economy gets a bit murky

There are manifold concerns around deep-sea mining

The Blue Economy is a term that seems to cover a multitude of different interpretations and definitions. The World Bank, in its 2017 report *The Potential of the Blue Economy* refers to it as "the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable". The European Commission on the other hand, in its 2018 *Annual Economic Report on EU Blue Economy* goes simply with: "All economic activities related to oceans, seas and coasts". Conventional merchant shipping obviously falls within the scope of that, but it's generally applied to the potential of emerging sectors, such as offshore energy and large-scale fisheries. Perhaps the most contentious of these is deep-sea mining.

The EU has identified deep-sea mining (i.e. 1-6km beneath the ocean surface) as a priority sector in its blue economy growth strategy. But it's hard to escape the misgiving that commercial players with an appetite to extract precious minerals from the seabed may be arguing their point more forcibly than environmentalists and others who want comprehensive research into all possible risks. As has been seen in the case of fracking on land, corporations with deep pockets have an uncanny tendency to assuage fears about the long-term consequences.

In February 2018, the European Parliament issued a non-binding resolution urging the EC to persuade member states to stop sponsoring and subsidising exploration licenses, whether they are in their own coastal territories or international waters. It called for an international moratorium "until such time as the effects of deep-sea mining on the marine environment, biodiversity and human activities at sea have been studied and researched sufficiently and all possible risks are understood."

Ultimately however, the European Parliament has no legislative influence when it comes to deep-sea mining in international waters. The International Seabed Authority (ISA), an organisation established in 1994 by the United Nations Convention on the Law of the Sea (UNCLOS) has responsibility for granting exploration contracts, but there is no obligation for operators to conduct an environmental assessment before commencing deep-sea mining. While to date mining activities haven't taken place in earnest, it's increasingly a case of when rather than if.

Concerns have been raised that IMO is being sidelined in this process. When UN delegates met in New York last September to discuss UNCLOS, International Chamber of Shipping (ICS) chairman Esben Poulsson sought to remind delegates that: "IMO should always be the lead organisation for developing environmental rules that may affect international shipping… IMO's jurisdiction is broad and extends already to shipping activity in areas beyond national jurisdiction."

ICS's apprehensions are partly about how its members may be affected by restrictions to their free movement in international waters. Plainly being forced to make changes to establish routes to navigate around mining areas could bring with it additional costs that goes counter to the efficiency drive of route optimisation. Notwithstanding this, much of the dicussion surrounding deep-sea mining seems to revolve around how the profits will be divided up rather than the environmental impact.

Where the environment is concerned it often boils down to a debate between what is possible to scientifically measure and what, if we had the technology and resources to do so, we would like to be able to measure. There's perhaps also a third element: that which we don't know we should be measuring – in other words, a somewhat Rumsfeldian dialectic of 'knowns', 'known unknowns' and 'unknown unknowns'. For some administrations, governments and corporations, the assurance that something 'appears' to be safe is sufficient, while others would prefer to wait until more information is available.

A couple of the articles in this issue (p.16 '*In search of quieter solutions*' and p.26 '*From propellers to underwater noise*'), for instance, touch on the subject of underwater noise, a burgeoning area of research and yet one which, until comparatively recently, the maritime community hasn't given serious consideration to. As HydroComp's technical director told me it's as much through a lack of knowledge in terms of which sounds, or sound ranges, may be causing harm to marine species. What's more, it could be that initiatives such as slow steaming, intended in part to curb emissions, are actually doing more harm in noise terms than a vessel operating at conventional speed.

It's a reminder that, in the overall scheme of things, we remain comparatively ignorant about the way our planet works and the insidious and irreparable damage which may be done by human activity. But ignorance cannot be a pretext for denial any more than inadequate regulations can be. It may not be possible to place global trade on pause but we can put far greater emphasis on the sustainable use of the resources already at our disposal before plundering the ocean for more. If not, we risk exacerbating an already critical state of affairs. *NA*

Regulations

Autonomous ships take the spotlight at MSC 100

The landmark 100th session of IMO's Maritime Safety Committee (MSC) has taken place against a backdrop of significant developments in the advance of autonomous ship technology.

While delegates were convening in London on the morning of 3 December, at an archipelago near Turku Finland, Rolls-Royce and Finnish state-owned ferry operator Finferries were conducting the first demonstration of a fully autonomous car ferry. Equipped with a range of advanced sensor technology, the 53.8m double-ended *Falco* completed the short voyage between Parainen and Nauvo. A shoreside captain monitored operations from Finferries' remote operating centre in Turku.

At MSC 100 itself, the process of assessing IMO instruments to see how they might be applied to ships with varying levels of autonomy continued. In particular, the Committee approved the framework and methodology for the regulatory scoping exercise of Maritime Autonomous Ships (MASS).

Ships will be graded according to their degree of autonomy, ranging from the simplest 'Degree one', where there are some automated processes and decision support for crew, to the fully autonomous 'Degree four', where the ship's operating system is able to make decisions and determine actions by itself.

The next step in the scoping exercise will be to analyse and determine the most appropriate way of addressing MASS operations, and what new or amended IMO instruments (e.g. SOLAS, COLREG, load lines) may be required. It is anticipated that the whole scoping will be completed in 2020. In addition, MSC noted there were now provisional principles for the development of guidelines for trials of MASS, with interested parties invited to submit proposals before the next session.

Other developments at MSC 100 included the adoption of revised guidelines for verification of conformity with goal-based ship construction standards for bulk carriers and oil tankers, based on the experience gained by auditors. In addition, the Committee considered a request from Sub-Committee on Ships Systems and Lifting Equipment (SSE) for help in drafting goal-based regulations for onboard lifting appliances.

The Committee also agreed that the agenda for MSC 101, which will take place from 5-14 June, will include a new item to explore measures to 'enhance the safety of ships relating to the use of fuel oil', with concerns raised about the need for greater guidance on the safety implications of the pending 0.5% limit of sulphur. However, the Committee was adamant this will not affect the implementation of the sulphur limit from 1 January 2020.

Finferries' *Falco* achieved a first for autonomous ships in December

Emissions

Maersk targets carbon neutral vessels by 2030

Danish shipping giant A.P. Moller-Maersk announced in December that it is aiming to have 'commercially viable' carbon-neutral ships in operation by 2030 and to achieve net zero CO_2 emissions by 2050.

The owner/operator called for strong industry involvement, the acceleration of new innovations and faster uptake of new technology in achieving the ambitious targets, far in excess of IMO's goal of a 50% reduction in greenhouse gas emissions by the middle of the century.

Maersk pointed out that its own relative CO_2 emissions have already been reduced by 46% from the 2007 baseline levels, compared to 9% of the industry overall.

But the company believes that efficiency improvements on current fossil fuel-based technology will only keep emissions at their current levels. "The only possible way to achieve the so-much-needed decarbonisation in our industry is by transforming to carbon neutral fuels and supply chains," said Søren Toft, chief operating officer at A.P. Moller-Maersk.

Toft added that the next 5-10 years will be crucial in ensuring that sufficient new vessel types are in service by 2050 and that in the past four years along Maersk had invested around US$1 billion, engaging more than 50 engineers, in developing energy efficient solutions. But he warned: "Going forward we cannot do this alone."

The SeaShuttle shortsea container vessel design

From this year, Maersk plans to initiate what it describes as "open and collaborative dialogue" with different industry players as it foregrounds research and development.

Container vessels

Samskip backs emissions-free shortsea vessel project

Container logistics firm Samskip is to act as the lead partner in Project SeaShuttle, an ambitious new initiative to develop commercially viable, emissions-free autonomous shortsea container vessels. Other partners include Kongsberg Maritime, logistics consultant FlowChange, hydrogen experts HYON and Kongsberg/Wilhelmsen autonomous shipping endeavour Massterly.

The project is part of the wider Norwegian 'PILOT-E' scheme, a collaboration between Innovation Norway, the Research Council of Norway and Enova, which will provide €100 million (US$114 million) of funding to initiatives that reduce emissions across trade and industry. SeaShuttle is set to receive €6 million (US$7 million) of funding from the Norwegian Food & Fishing, Climate & Environment, Petroleum & Energy, and Transport & Communications ministries.

As suggested by its name, Project SeaShuttle's focus is on shortsea shipping, specifically between the Oslo fjord, the west coast of Sweden and Poland. The vision is of a fleet of all-electric container vessels powered by hydrogen fuel cells, operating autonomously between ports in these locations. Initially, two demonstrator vessels will be developed, with electrolysis of the hydrogen planned to take place in Norwegian ports for the time being until hydrogen becomes more readily available along the vessels' routes. This will allow for complete emissions-free voyages, which would currently only be possible in Norwegian waters.

Part of the project's impetus is to challenge the truck ferries that currently operate in the Baltic. According to Samskip Norway's managing director Are Grathen, 2,000 truck loads pass through Norwegian ports every day, which could be better served by shortsea vessels. "Exporters increasingly seek lower and even zero emissions transport solutions, but they need to be assured on reliability, frequency, efficiency and cost effectiveness," he says.

A further reason for conducting the project is to pave the way for hydrogen fuel cell use on larger vessels on global trade routes, which if achieved would provide a significant boost to shipping's environmental credentials. Marius Gjerset of the Zero Emissions Resource Organisation says: "This is an important milestone on the long sailing to make the maritime sector emissions free. We believe hydrogen and fuel cells are the future for large and long-distance ships, and we need projects like this in order to solve technical and practical issues."

Ship surveys

New Year sees DNV GL roll-out Smart Survey Booking

From the 1 January, DNV GL's Smart Survey Booking (SSB) system became available to all maritime customers following a successful trial period with the likes of Wilhelmsen and Hapag-Lloyd.

SSB is accessible via the classification society's My Services portal, hosted on its Veracity data platform, and will replace conventional email and phone-based survey bookings. The system is part of a wider strategy of digitilisation at DNV GL, which, according to Director of Approval in Maritime, Rasmus Stute, "is one large opportunity to increase efficiency when it comes to compliance."

At a press event held by DNV GL in Hamburg in December, Stute explained SSB as "bringing together machine learning and the survey booking process". The new system is able to notify shipowners of the best 'smart survey window' – the optimal timeframe in which to complete surveys necessary to achieve compliance – therefore reducing downtime. This is underscored with cost model analysis, a feature "often requested by our customers" said Stute, which considers port and surveys fees to suggest the cheapest combination of location and (DNV GL approved) service provider.

Stute pointed out that the system does not wait for shipowners to plan surveys, but rather offers "a proactive notification that we bring forward to our customers in order to notify them when the best

window is to carry out a certain number of surveys." To ensure the smooth completion of these surveys, DNV GL will also create "checklists to send to the crew so they are very well-prepared."

The Hamburg event also saw DNV GL discuss its use of drones in surveys, particularly of fuel and cargo tanks. 2016 marked the first use of a drone onboard the chemical tanker *Apollo*, and the class society has since established drone teams in five service hubs (Shanghai, Singapore, Dubai, Gdynia and Houston).

In tank surveys, drone use eliminates staging cost and damage, replaces the need for rafting, and improves safety as surveyors don't have to go up high. However, drone surveys are still fairly limited in their scope, requiring the presence of a surveyor, access to tanks, and manual data handling following the survey.

Future possibilities being explored by DNV GL to render drones a more viable solution include virtual reality to allow remote surveyors to 'see' through the drone, which could also be piloted remotely or programmed to operate autonomously. Drone-based 3D mapping, coupled with corrosion and crack identification software and machine learning, is also envisaged, allowing the creation of an actionable digital model. At a higher readiness-level is a project to enable drones to perform steel thickness measurements, greatly simplifying this procedure in hard-to-reach areas. *NA*

DNV GL's Director of Approval, Rasmus Stute, discussing drone-based surveys

Back to the future

Malcolm Latarche reflects on the renaissance of wind power and the role it could play in decarbonisation

Around this time of year, it is customary to look back over recent events and forward to the future. Although shipowners are currently most concerned with preparing their strategies for meeting the 2020 sulphur fuel cap, arguably the most significant event as of last year was the IMO's adoption of a decarbonisation goal.

Efficiency and reducing CO_2 emissions are not a new addition to the IMO agenda but there had been a limit set by the EEDI rules which reach their conclusion in 2025. Most thought that the final goal of a 30% reduction in CO_2 emissions would be met by a gradual switch to LNG as a fuel complemented by some efficiency improving design changes. The adoption of a more aggressive CO_2 reduction policy means that idea is no longer valid and alternative means need to be found.

The last months of 2018 have seen an uptick in wind powered projects and concepts. Sails have never disappeared entirely, but it is almost a century since the last commercial sailing ship *Padua* was built in 1926. In the past, a resurgence of sail projects usually only happened when oil prices skyrocketed but none were successful and interest waned once fuel prices dropped back. This time around it looks different. Tankers, bulk carriers, general cargo ships and new passenger vessels are being fitted with either sails or Flettner rotors. Importantly, cargo interests are lending support to projects rather than owners acting alone.

For example, in late November, French car maker Renault announced a three-year project with Neoline to develop a 136m ro-ro ship with 4.200m^2 of sail area for carrying vehicles on Trans-Atlantic routes. The ship would also have a 4,000kW diesel electric propulsion system to ensure reliable transit times but seemingly under most conditions the ship would reduce CO_2 emissions by around 90% compared to a conventional vessel of similar capacity.

Another project of interest that has attracted support involves the Danish shipowner Ultrabulk and UK power station operator Drax, along with a racing yacht specialist and the Smart Green Shipping Alliance. In this case the project is a year-long feasibility study for fitting sails to a bulk carrier.

Modern solid sail technology is also being trialled on *Le Ponant,* the 89m sailing cruise vessel which is the flagship of French cruise operator Ponant. This project is in conjunction with Chantiers de l'Atlantique and is a revival of the shipbuilders' Silenseas project announced earlier this year before the Fincantieri takeover of STX France as the yard was then known. STX France had been working on sailing cruise vessels for several years and had patented the Solidsail concept. At the time of announcing the project, STX France had said the sails could reduce fuel use by around 60% when combined with batteries and automation. Since cruise ships seem to have taken the innovation baton from offshore, it may well be that the Silenseas project will someday proceed to maturity.

Flettner rotors were first used in 1925 but despite proving the science behind the concept, rotors were not an economical success and disappeared within a very short time. The revival that began about 10 years ago has in fact seen more successful installations than the original but there are very good reasons for that.

The rotors do not harvest free energy and need power to rotate. In all of the vessels that have been fitted with them since 2010, including the cruise ferry *Viking Grace* and LR tanker *Maersk Pelican* both installed this year, the rotors are there as a supplement to the main engines rather than the main propulsion source. That said, in mid-December, the initial results of trials of a Flettner rotor fitted to the 4,200dwt general cargo ship *Fehn Pollux* were made public.

The rotor was fitted as part of a research project funded by the EU. In the six months since the rotor was fitted, data has been collected continuously on its operation, prevailing conditions and fuel consumption. The data is being used to develop an algorithm that automatically controls the speed and direction of rotation to ensure that the rotor makes the maximum contribution possible to the ship's propulsion efficiency. Professor Michael Vahs of the University of Applied Science in Emden/Leer in Germany, which is processing the data and developing the control system, said that on occasions the rotor was producing more thrust than the ship's main engine.

In future, when excess energy stored in batteries could provide the power for the rotors, they may prove even more efficient. However, acceptance is not guaranteed and whether sail or rotors, ship design may need to adapt to take account of permanent deck mounted structures that could alter the dynamic behaviour of vessels as well as their possible effect on cargo operations. NA

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Exhaust gas recirculation

First order for unique two-stroke EGR system

Japan Engine Corporation (J-ENG) has confirmed that it has received the first order for its Low Pressure EGR System, dubbed LP-EGR – the only such exhaust gas recirculation system able to be used with two-stroke marine diesel engines. The order, made by Oshima Shipbuilding Co., Ltd., will see a 7UEC60LSE-Eco-A2-EGR engine utilising the system delivered to a 99,000 dwt bulk carrier, to be operated by NYK Line.

As well as being a low pressure and temperature unit, requiring minimal maintenance, a key advantage of LP-EGR is that it enables shipowners to achieve IMO Tier III NOx compliance, which applies in the North American and US Caribbean Emission Control Areas (ECAs) for vessels keel laid after 1 January 2016. 2021 will see Tier III compliance extended to the North Sea and Baltic Sea ECAs, again for vessels built after 1 January 2021. Despite the reduction in NOx from Tier II levels, increase in SFOC is carefully controlled.

In the dedicated Tier II mode – meeting the global requirement – the exhaust gas recirculation ratio can be lowered in order to achieve an improved balance between SFOC and a compliant level of NOx emissions reduction.

In a further environmental move, LP-EGR anticipates future restrictions by requiring no waste water drainage from the water treatment system in the unit. This speeds up outfitting as the necessary piping is reduced.

J-ENG has stated its willingness to supply the system to rival engine manufacturers, to encourage more widespread meeting of NOx Tier III requirements.

www.j-eng.co.jp/en/

Operational data

Høglund-Yxney agreement to improve fuel data visibility

A recent agreement signed by Norwegian companies Høglund Marine Automation and Yxney Maritime will see the former's fuel consumption data platform integrated with the latter's cloud-based processing software, leading to improved access to valuable insights for shipowners.

The new 'plug-and-play' solution has been dubbed 'SPM-MarESS', combining its constituent parts of Ship Performance Monitor and MarESS. It is stated to improve decision-making and ship/fleet fuel efficiencies by providing fuel consumption data and analytics, which are clearly presented on a user-friendly interface so as to provide usable insights.

Commenting on the partnership, Yxney CEO Gjord Simen Sanna said: "We see this partnership as an answer to the demand among vessel owners to take control of their own data, and to get ahead in the race towards better fuel efficiency and lower emissions. Combining our solutions gives our customers access to new decision-making feedback, driven by data analytics, to make more direct fuel-saving initiatives."

A number of companies have reportedly shown interest in SPM-MarESS since it was launched, including Havila Shipping, which signed a five-year contract, and Siem Offshore.

The new product represents a wider trend in the industry of utilising operational data to drive efficiency and improve profit margins. This is particularly essential given the smaller efficiency gains being achieved by equipment manufacturers, particularly in the case of engines, and the costs shipowners are facing as they transition towards alternative fuels or retrofit environmental technology to meet the 2020 sulphur cap.

In a further announcement in December, it was confirmed that Yxney is now to be part-owned by fellow Norwegian company UniSea, which develops software to optimise work processes in the shipping industry.

hma.no / yxney.com

Ballast water treatment systems

USCG approval for De Nora's Balpure

Italian technology company De Nora has announced that its proprietary electrochlorination-based ballast water treatment system (BWTS), Balpure, has received US Coast Guard type approval. This makes the BWTS the 15th system to join a growing group of compliant systems, rendering it an option for ships operating in the USA or that are US-flagged.

Testing of the system took place on a US-flagged Aframax tanker ballasting and deballasting in locations along the west coast of the United States including California and Alaska. In a boost to the system, it has been identified by the Environmental Protection Agency's (EPA) Science Advisory Board as being able to meet a standard 10 times 'more stringent' than IMO's D-2, which regards the levels of viable organisms present in ballast water after treatment.

An electrochlorination-type system, Balpure utilises what is known as the 'slipstream' method, in which only a small amount of seawater passes through the electrochemical unit (between 0.5-1%). The required amount of the treatment chemical, hypochlorite, is generated in the slipstream and mixed with the rest of the ballast water. Because no hypochlorite need be stored on board, waste is

reduced and efficiency improved. The technology has been marketed particularly towards large tankers, LNG carriers, and bulkers.
denora.com

A skid-mounted version of the approved Balpure BWTS

Propulsion

New expedition vessels to feature Rolls-Royce power and propulsion

Portuguese cruise company Mystic Cruises has opted for a suite of Rolls-Royce technology to equip two new 16m expedition cruise vessels contracted at WestSea Yard. The 200-guest vessels are part of a series of three, the first of which, also fitted with Rolls-Royce equipment, is nearing completion. The total value of the contract is £14 million (US$17.5 million).

Rolls-Royce's scope for each vessel includes two C25:33L8P main engines and a C25:33L6P auxiliary dual generator manufactured by Bergen. A low voltage AFE SAVeCUBE power electric system will enable engine operation at variable speeds depending on power requirements, to increase propulsion efficiency.

Each vessel will also feature two Rolls-Royce controllable-pitch-propellers, flap rudders, steering gears and tunnel thrusters, which together make up the Promas propulsion system concept. The system reduces flow separation, allowing an increase of propeller thrust by recovering wasted energy. Finally, Rolls-Royce will supply an automation and control system.

The main driver to install the equipment for Mystic Cruises was the ecologically sensitive areas that the vessels will operate in. "We are going to cruise some of the purest and most beautiful regions of the world," said Mystic Cruises CEO Mário Ferreira. "To reduce our impact, we worked with Rolls-Royce to integrate an ultra-sophisticated hybrid propulsion system that dramatically reduces fuel consumption and CO_2 emissions, as well as a dynamic positioning system that allows us to avoid using anchors."
rolls-royce.com

Scrubbers

Yara Marine targets Asian scrubber market

Norwegian scrubber manufacturer Yara Marine Technologies has opened a new office in Shanghai, China, in order to establish a local presence in the world's most significant market for exhaust gas cleaning systems.

As well as enabling the company to support existing customers in the region with equipment maintenance, the new office will allow Yara to benefit from an expected increase in demand for scrubbers as the 2020 sulphur cap approaches. The continuing primacy of Asian shipyards – particularly Chinese – also means that Yara will now be closer to the majority of retrofit and newbuild projects involving scrubbers.

A full range of functions will be undertaken from the new location, including sales, procurement, service/commissioning, and engineering. Michael Chang has been appointed as general manager.
yaramarine.com

An 3D mock-up of Mystic Cruises' new expedition vessel series

In pursuit of quieter solutions

As part of its ongoing efforts to protect the marine environment, Canada is hosting a technical workshop on quiet ship design and retrofits at IMO

Underwater noise has been identified as a significant cause of the plight of the southern resident killer whale

Sound in the world's oceans originates from many sources, such as storms, animals, earthquakes, commercial shipping, marine construction, military activities, oil and gas exploration and production, and even clouds of bubbles. Sound travels through water far better than does light, which is why many marine organisms rely on their hearing to find prey, to avoid predators, and to communicate.

Measurements taken over the last 50 years indicate an increase in some areas in anthropogenic noise emissions into the marine environment. The main sources include vessel traffic, seismic exploration, industrial activities and construction (e.g., pile driving, drilling, tunnel boring, dredging), military and commercial sonar, acoustic deterrent devices, oceanographic experiments, and explosions for underwater construction. While high intensity, impulsive noise sources, such as seismic testing and pile driving, are thought to pose the greatest risk of acute injury (Southall et al., 2007), lower levels of continuous, chronic noise have created serious health impacts for marine mammals. The largest contributor of anthropogenic noise to the marine environment is conclusively commercial shipping, particularly in the low frequency range (Ross, 1993, 2005; Andrew et al., 2002; McDonald et al., 2006, 2008; Hildebrand, 2009; Chapman & Price, 2011; Frisk, 2012).

Underwater noise from commercial shipping has the potential to adversely impact a variety of aquatic animals including whales, fish, turtles and invertebrates, that use sound to communicate, navigate and forage. For Canada, one species in particular – the southern resident killer whale (SRKW) – is facing imminent threats to its survival and recovery, with one of these key threats being underwater noise from vessels. This has prompted the Government of Canada to take action.

Since 2017, Canada has been taking a leadership role in advancing discussions and actions on reducing underwater noise from vessels to better protect the marine environment and help support the survival and recovery of the SRKW. For example, in partnership with the Vancouver Fraser Port Authority's Enhancing Cetacean Habitat and Observation program (ECHO), and following a pilot project which demonstrated that reducing speeds can result in significant underwater noise reductions, an annual voluntary slowdown in a key area of the critical habitat of the SRKW has been implemented. However, operational measures such as slowdowns are sometimes restricted as a result of geography or due to the classes of ships that transit within a particular area. Quiet ship design and retrofits therefore present an opportunity to address the principal source of underwater noise on a more global scale.

The 2014 International Maritime Organization (IMO) Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life (MEPC.1/Circ.833) (the Guidelines) rightly identify that the largest opportunities for reduction of underwater noise will be during the initial design of a ship. To this end, the Guidelines pinpoint several

design areas that are likely to reduce a ship's underwater noise emission, such as:

1. Propellers designed and selected in order to reduce cavitation.
2. Ships with a controllable pitch propeller with variability on shaft speed to reduce operation at pitch settings too far away from the optimum design pitch for efficiency.
3. Hull forms with appendages designed such that the wake field is as homogeneous as possible.
4. On-board machinery and equipment optimised based on its accessibility for regular maintenance and lubrication, as well as its susceptibility to remain in optimal operating conditions.
5. Advanced propulsions systems, such as diesel-electric with high-quality electric motors incorporated, instead of conventional less-efficient systems.
6. Four-stroke engines (in lieu of 2-stroke engines [when available]) mounted on flexible couplings and resilient mountings.

The IMO's adoption of the Guidelines has been useful to identify ship designs, technologies, and operations that are likely to reduce underwater ship noise. New additional evidence to support and expand upon them, however, has emerged while certain aspects of ship designs and related technologies are likely to have changed.

Ship design and technology workshop

Canada sees this as an opportunity to leverage and innovate. To gather and share recent research conclusions and assess current and future quiet ship designs, Canada will be hosting an international workshop from 30 January to 1 February 2019 at IMO Headquarters. This workshop presents a unique opportunity to bring together naval architects, marine engineers, ship operators, shipyards, national policy makers, industry associations, academics, and non-governmental organisations to share their breadth of expertise with diverse viewpoints and lead to a more complete and accurate assessment of the current state of, and opportunities for, innovative designs and technology.

This forum will provide an opportunity for international collaboration and allow participants to share the newest research and technical solutions for more quiet ship design and retrofits. The specific objectives of the proposed workshop will include, but are not necessarily limited to:

1. Validating current technologies and identifying important gaps and challenges to further progress;
2. Assessing areas for innovation potential to determine where more focused research may be needed;
3. Understanding and quantifying whether improvements made to ship design for fuel efficiency overlap with improvements made to reduce noise; and
4. Documenting the conclusions of the workshop to guide future discussions on reducing underwater ship noise or as groundwork for a review of the existing Guidelines.

For more information on the workshop, including how to register, or if you have any questions about the work that Canada is undertaking in the area of underwater noise more broadly, please do not hesitate to contact Transport Canada at: TC.QuietShips-Navires silencieux.TC@tc.gc.ca. *NA*

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World's first intelligent VLOC delivered

Following on from the groundbreaking bulk carrier *Great Intelligence*, a new SDARI-designed intelligent very large ore carrier, *Pacific Vision*, has been delivered by Shanghai Waigaoqiao Shipbuilding

On 28 November 2018, *Pacific Vision*, the world's first 400,000-ton 'intelligent' very large ore carrier (iVLOC), was named and delivered in Shanghai, heralding a new era in Chinese smart ships. Designed by the Shanghai Ship Research and Design Institute (SDARI) and built by Shanghai Waigaoqiao Shipbuilding Co Ltd (SWS), a subsidiary of China Shipbuilding Industry Corporation (CSSC), the vessel is owned by China Merchants Energy Shipping Co Ltd.

Pacific Vision has an overall length of 362m, a width of 65m, a depth of 30.4m, a draught of 23m, a speed of 14.5knots and a battery life of 25,500nm. The vessel was built around three major themes: common technology, key systems and demonstration applications. In following the China Classification Society's (CCS) 'Smart Ship Code', the ship has realised five major 'intelligent module' functions: auxiliary automatic operation, energy efficiency management, equipment operation and maintenance, ship-to-shore communication, and cargo liquefaction monitoring. It also complies with international Ship Monitoring – Reporting – Verification (MRV) rules.

Left: The world's first 400,000tons of intelligent super large ore ship (VLOC) *Pacific Vision*
Right: *Pacific Vision* in navigation

Six breakthroughs

On 28 November 2017, the world's first intelligent merchant ship, the 38,800 DWT intelligent bulk carrier *Great Intelligence* (see February 2018's *The Naval Architect*) was built by CSSC Huangpu Wenchong shipbuilding. The ship has broken through the key technologies of information sharing, self-assessment and decision-making, ship-to-shore integration, etc., and completed the independent development and integration of the whole ship intelligent network, intelligent operation and maintenance system, intelligent navigation system and host remote control system. The ship obtained CCS and Lloyd's Register's (LR) intelligent classification symbols.

On the basis of *Great Intelligence*, *Pacific Vision* achieved breakthroughs in six aspects. First, the concept of 'platform + application' was proposed and applied to the ship. The platform unifies the collection, processing and analysis of ship operational data, providing it to each intelligent system to solve the problem of information duplication. Secondly, for the first time, collision avoidance decision support software has been applied, which provides the crew with anti-collision suggestions to help reduce navigational safety incidents and lays a technical foundation for the next step – independent/autonomous collision avoidance.

The third breakthrough is the realisation of ship-to-ship communication, to enable direct communication between the ship and other ships at sea, further aiding collision avoidance. The fourth is the application of a cargo liquefaction monitoring function; by monitoring the degree of liquefaction of minerals in the cargo tank, including iron ore and nickel ore, it provides suggestions to the crew to solve ship stability problems. The fifth development regards effective transmission of ship-to-shore communication, with advanced encryption, which provides a reliable data source for the future construction of shore-based data centres. Sixth, the smart ship symbols of CCS and DNV GL were obtained at the same time.

Special project

Pacific Vision is the first demonstration ship of China's Intelligent Ship 1.0 Special Project, set up by the Ministry of Industry and Information Technology in 2016 to organise the primary institutions of the shipbuilding industry, intelligent system development units, shipbuilding groups, academic institutions, etc. to jointly carry out research on smart ships. CSSC is the organiser and main participant of the project. Waigaoqiao Shipbuilding (SWS), Shanghai Ship Research and Design Institute (SDARI), China Shipbuilding Systems Engineering Research Institute (SERI), together with China Merchants Energy Transportation, Beijing Hailanxin Data Technology, Shanghai ship industry leaders such as the Transportation Science Research Institute (SSSRI), CCS, and Harbin Engineering University, have taken advantage of their respective strengths to fully promote the research and development of the project.

Industry experts said that the Intelligent Ship 1.0 Special Project will enhance China's ability to design, build, operate, maintain and manage smart ships, as well as the autonomy, safety and controllability of core products. At the same time, via *Great Intelligence* and *Pacific Vision*, research on intelligent function modules and systems will drive coordinated development of the whole industry chain and enhance the comprehensive competitiveness of China's shipbuilding industry. ***NA***

Bringing transparency to maritime procurement

TNA speaks to Freddy Ingemann, CEO of Moscord: an online marketplace hoping to modernise maritime procurement through data and lean logistics

Shipping is unique in many respects – often positively so. However, for Moscord CEO Freddy Ingemann, the industry is clinging on to one less welcome behaviour. "The ship supply business is the only business left where you are hiding your prices," he says. "In all other business it is transparent."

In an era where widespread digitalisation has opened up the free exchange of information in both industry and society, strategic opacity seems to be on its way out. Yet, as Ingemann points out, ship suppliers leverage the status quo in the maritime industry to gain a commercial advantage – to the detriment of the shipowner.

With over 15 years' experience of innovation in the procurement sector gained at ShipServ, Ingemann is hoping to make a change with his new venture. Referred to by some as 'the maritime Amazon,' Moscord is an online platform that enables procurers to buy ship supplies directly from manufacturers and wholesalers.

Crucially, products available on the platform are pre-priced, and owners have the ability to negotiate directly with suppliers. The price paid also includes 'last mile' delivery, in which Moscord consolidates all products ordered at a proprietary port hub and sends them directly on to the vessel.

A further important aspect of the offering is the integration between Moscord's platform and the ship's existing purchasing software, including popular services such as Sertica, SpecTec's Amos and Shipnet. This integration makes it easier for owners to implement Moscord into existing workflows, and reflects the fact that "you will never get a marine purchaser to go and just buy online with their credit card," says Ingemann.

At present, the product list on the platform is relatively limited, taking in valves, electric motors and components, filter cartridges, and consumables. Pending an agreement with power management multinational Schneider Electric, however, total product numbers will reach approximately 100,000.

Freddy Ingemann, CEO of Moscord

In the near future, Moscord is also set to offer 'service', including spare parts and engineering, as a purchasable item.

For buyers, using Moscord is free. The company's business model operates by charging suppliers a fee, who then should be able to access a wider marketplace and secure repeat business. It is important, says Ingemann, that suppliers "should have more value in return" despite paying; the platform allows them to operate a direct model without the administrative burden of logistics and delivery.

Data plays a significant role in Moscord's optimisation of the procurement process. Reflecting e-commerce best practice, all product entries are written in a standard format and are organised/categorised effectively, ensuring products are searchable.

Moreover, entries are continually updated to ensure they feature accurate product information. This allows Moscord to minimise wrong-part delivery, which is a significant problem across the ship supply business; according to Ingemann, "as much as 20% of final deliveries are returned because the wrong items are specified due to wrong or missing data."

By working directly with suppliers, Moscord also guarantees product provenance, unlike resellers who often sell second-hand or generic parts that may not have been manufactured to the same quality standards. "The customer should also know what they get," says Ingemann. "If you order an ABB motor, you should get an ABB motor and not an unbranded motor." This works the other way, too, he adds: "It's also important for suppliers to know who buys their product."

The second underlying aspect of Moscord is lean logistics: "It's not enough to display the product data online on our business," says Ingemann. "[Products] have to get out aboard the ship." Ingemann believes that conventional logistics is conducted in a highly inefficient way, over-utilising air freight, sending products in separate packages, and paying more for delivery than the value of the product itself.

As such, Moscord's delivery strategy revolves around using international logistics companies with global presence, who can deliver to any of the 'port hubs' Moscord plans to establish. The largest company with which it has an agreement is Gulf Agency Company (GAC), which claims access to 1,000 ports around the world. Local logistics firms will also be used to ensure a leaner chain.

Moscord is, essentially, an expression of the competitive, free-market principles, that the supply business hasn't always followed. "The product has a price," Ingemann states, "and the guy who can produce the product most efficiently with the most lean logistic chain should win the order." By providing part of this 'lean logistic chain', Moscord removes unnecessary overheads for suppliers, allowing them to price competitively and win orders. Tech may begin to play a greater role, too; Ingemann foresees dual-pricing between conventional parts and 3D printed versions, which can be manufactured and delivered rapidly, therefore commanding higher prices.

E-commerce may not have broken into shipping to the extent that is has in the consumer goods industry, but with a platform dubbed the 'maritime Amazon' seeing rapid growth, this may now be set to change. *NA*

A problem of their own making?

High levels of competition, combined with the financial effects of the Ballast Water Convention extension, have forced ballast suppliers to lower their prices. For shipowners, this means savings – but failures to prioritise system suitability threaten to exact a much higher price

Given that ballast water treatment has been on the shipping industry's agenda for decades – and is now mandated by the long-overdue Ballast Water Management Convention – it is surprising that the practice is still causing a plethora of issues for suppliers and, perhaps more so, for shipowners.

Years of dawdling legislative progress have enabled them to delay installation, and now shipowners of existing vessels (i.e. built before the Convention's coming-into-force date of 8 September 2017) have further benefitted from the universal two-year extension, and in individual cases up to five-year extensions, granted at MEPC 71, which has been tacked on to the compliance date for installing a ballast water treatment system (BWTS). This date is now tied to a vessel's first International Oil Pollution Prevention Survey after 8 September 2019, which some owners (supported by their flag states) have strategically de-coupled from the Harmonised System of Statutory Certificates (HSSC) system to buy extra time.

For suppliers, these continual extensions – and the widespread exploitation of the HSSC loophole – have been immensely damaging to their businesses, and the cause of much anger. Many were relying on the rollout of the Convention to deliver their first payday since 2004, and were consequently hit hard by the lack of a much-needed ordering boom.

Speaking recently with *The Naval Architect*, Coldharbour CEO Andrew Marshall expressed his frustration with the flawed implementation of the Convention: "IMO have fundamentally got this wrong. They allowed owners to play sport with it for year after year – it was the longest running unratified convention in IMO history. And what has happened since 2004? They ratified it in '15, rescinded it in '16, re-ratified it in '16, and delayed it in '17. That's no way to run a chimp's tea party, let alone an internationally vital piece of legislation."

The endless detours on the path to the Ballast Water Convention sank Oceansaver AS, but the eponymous BWTS, pictured, has been saved by TeamTec

Amidst the chaos, staying afloat proved impossible for some suppliers. Norway-based OceanSaver AS, for example, officially filed for bankruptcy in September 2017 after its main investor pulled out. This occured despite OceanSaver's electrodialysis-based BWTS being one of the first IMO and US Coast Guard (USCG)-approved systems, and therefore part of an elite group of fully compliant BWTS.

The OceanSaver BWTS has since been 'rescued' by IMS Group-owned technology company TeamTec, which manufactures scrubbers, incinerators, and stripping ejectors. Edvin Tønnessen, TeamTec's head of sales and projects for OceanSaver, believes the system now has a much more promising future. "A company with several products in their portfolio has a much larger chance of succeeding in the business," he says. "Single-product companies are marketing that [their way] is the best, but at the same time you have an administration and a company you will need to cover selling products at low margins in a very competitive market."

As Tønnessen suggests, the premature competitiveness of the BWTS market coupled with unexpectedly slow demand has led to low margins across the board, as suppliers battle to gain references and turnover. When the future ordering rush does occur, these references will theoretically allow suppliers to secure future business.

Suppliers without USCG type approval in particular have been "selling at very low prices to compensate for the lack of approval," says Tønnessen. Suppliers with approved systems, however, have reported a positive effect. French supplier Bio UV Group, for instance, released a financial statement showing an increase of 30% in its revenues in Q3 of 2018 compared with the same period in 2017. Chief executive Benoît Gillmann has since directly attributed this growth to USCG certification, which was granted in June. However, the ability to actually raise system prices isn't guaranteed, with Tønnessen citing a supplier who "openly said that they had been hoping to increase their prices once the approval was in place, but they found it not possible."

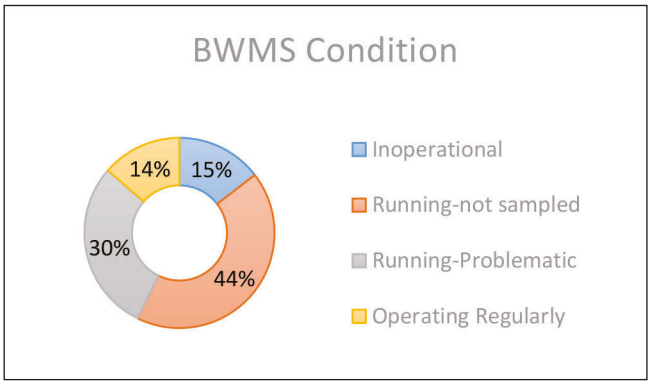
In Marshall's opinion, low system prices have come about because of strategy as well as necessity. "You have some very artificially low-priced systems floating around the marketplace," he says. "Some of those are due to manufacturers being quite aggressive, and others are because some manufacturers receive more local support." As will be discussed below, common yard practices related to BWTS for newbuilds compound this problem.

A buyer's market?

Given the above, suppliers' pain would seem to be shipowners' gain. With far more time than expected to achieve compliance, and a choice of cheap systems (for all vessel types) offered by suppliers hoping to undercut one another, it would appear straightforward and trouble-free for shipowners to satisfy their ballast water treatment requirements at little cost.

However, a spate of ballast-related issues to date proves otherwise. The question to ask is whether these issues are the result of shipowners' attitude to compliance with the Ballast Water Convention.

Certainly, the most significant ballast-related issue to date for shipowners has been the high rate of BWTS operational failure. The extent of the issue was highlighted by an ABS report published last year entitled '*Best Practices for Operation of Ballast Water Management Systems*'. 27 owners, having over 200 vessels with BWTS installed, were surveyed by the class society, returning figures showing that 30% faced 'problematic operations' and 15% of systems were 'inoperable' (see pie chart). Marshall suggests that "if you just look at the big stuff" such as VLCCs, "that percentage of failure doubles."



ABS' 2017 report contains an owner survey which suggests that 30% of BWMS face problematic operations (Best Practices for Operation of Ballast Water Management Systems)

As to the causes of this high rate of failure, the ABS report states: 'The more prevalent challenges that shipowners and operators have faced with these systems are related to software, hardware, and the crew's ability to operate the systems correctly. The software integrated into the ballast water management systems which were analysed in this study often required extensive updates, and experienced system malfunctions. System operators have had a difficult time with hardware maintenance and maintaining appropriate spare parts onboard.'

Software issues, whilst increasingly problematic for today's digital ships, are experienced across different technology and arguably reflect a wider issue with technological readiness rather than a particular failing on the part of ballast systems.

As for the question of hardware, a discussion took place at the Global Maritime Environmental Congress (GMEC) at last year's SMM exhibition highlighting the common use of non-marine grade materials in ballast systems. According to Choice Ballast Systems' Debra DiCianna, "we are finding that yards are substituting materials for some minor components of ballast water systems to non-marine grade during installations of ballast water systems on board vessels that have caused system operation failures." Tønnessen offers that this is because "you will find many suppliers that are used to delivering their products to land-based customers only, and find it hard to adjust to their maritime customers."

The report goes on to state that 'the biggest takeaway resulting from the responses was the necessity of maintaining an effective training system to ensure crew members can operate the equipment properly and safely.' Predictably, training (or lack thereof) tends to be the reason highlighted by suppliers in response to BWTS failures. For instance, at a recent Immediasea roundtable in London, Optimarin CEO Tore Andersen claimed that owners "don't spend €5 on training their crew […] It seems like with ballast water, it is expected that the training just comes into the ship by itself." Andersen was keen to point out that Optimarin offers training opportunities at two strategically located centres in Mumbai and Manila, but that surprisingly low numbers of shipowners avail themselves of the opportunity.

Marshall, though, argues that ballast problems begin much earlier than training. "The devil will be in the detail," he says. "Some manufacturers are complaining that owners won't invest in training, but what comes first, the chicken or the egg? How many system failures are down to owners not training their crew, and how many are down to the fact that the system was never going to work?"

If a system was "never going to work," it is because it is not fit-for-purpose for the vessel and at odds with its operational profile. Factors to be taken into account when selecting a BWTS include the size of the vessel and its cargo capacity, the attendant flow rate required whilst loading and unloading, the temperature and salinity of the water being operated in, the time

between port operations and therefore the available ballast water treatment window, and relevant jurisdiction, requiring, for instance, a USCG-approved system.

Both Marshall and Tønnessen contend that, because shipowners are motivated first and foremost by the price of a system, they do not pay enough attention to these essential considerations. "Far too many people are saying 'it's cheap, it's got type approval, I'll have it. What is it?'," says Marshall. "If it's not fit for purpose for the vessel you are going to install it on, and for the way you are going to operate that vessel, you are going to have a nightmare." This 'nightmare' is likely to be both financial and logistical, Tønnessen adds: "Saving a few tens of thousands USD on system purchase can be lost in just hours if the system fails in the wrong port – with delays, penalties, and possibly a full exchange before returning to the port."

At MEPC 71, IMO secretary-general Kitack Lim stated that the extension to the compliance date "clearly demonstrates that the Organization is leaving no stone unturned to provide both regulatory certainty and enhanced confidence in the workability of the Convention's provisions"

A higher cost

Can it be true that shipowners are concerned with price, to the extent that they disregard or fail to adequately consider system suitability? There is certainly an argument to be made. However, other forces have also a played a part in the BWTS failures crisis.

For one, the emphasis placed on type approval – whether USCG or IMO G8 – has arguably resulted in shipowners misinterpreting the certification process, believing it to mark all the systems in this relatively small group as being compliant, suitable, and high quality. Tønnessen explains: "Systems that have passed the USCG tests have passed an important bar, and have proven that the system works in the required conditions. Still, the USCG type approval is what it is – an approval of systems within given parameters. The general quality of each system is of course not tested." While having an approved system is essential for certain vessels, it does not mean that all approved systems will be equally valid, nor that all these systems have high quality materials, software, and ease of operation. Marshall adds: "I know wrong systems have been installed on a vessel just because they are type-approved."

Shipowners contracting newbuilds, too, face their own particular challenges when it comes to BWTS decisions. For instance, in the large tanker and bulker sector that Coldharbour operates in, which sees upwards of 80% of its newbuild activity in China, Korea and Japan, Marshall notes: "Most of the major yards have their own brand of BWTS, and then they've got a shortlist of others that they will tolerate. Whether all of those are suitable for the vessel in question is open to debate, but not open to negotiation. Typically speaking, the yard will throw in a monster price for incorporating the equipment of choice that the owner wants to have. Your selection of equipment might have added a little to the price overall naturally, but the delta will show as several million rather than several hundred thousand."

Even for a shipowner initially willing to pay more for the most fit-for-purpose system, such a large price increase is almost impossible to justify. This is particularly true for BWTS since they offer no monetary return in conjunction with their environmental benefit, unlike scrubbers, for example, which can be paid off in as little as a year due to fuel cost savings. Even in the case of existing ships, an owner with an older vessel may opt to take fines rather than undergo a full drydocking and pay for a new system.

Blame game

It is tempting to conclude that, by pushing for IMO to extend the compliance date for the Ballast Water Convention, shipowners have created a BWTS market that is actually working against their best interests.

In fact, a number of different factors have conspired to create the issues discussed. In addition to shipowners' unwillingness to accept the Convention, the pressure to fit a type-approved system, the lack of payback on the system, protectionism from yards affecting the market and unscrupulous suppliers seeing BWTS as a cash cow are all playing a part. Marshall admits that owners are in a difficult position; under pressure to save costs, a system can seem very attractive if the supplier says it is suitable and fully compliant as well as cheap. However, Marshall advises shipowners in future to "get their act together and get tough", being clear about what system they need and want, and refusing to deal with yards that deny them their choice.

"The truth is out there if you're willing to hear it," Marshall says. "It doesn't have to be a nightmare, and there are very good people involved in the ballast water treatment sector who will make sure you get what you need." *NA*

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Lost in the stars

CASD software sits at the centre of an ever-expanding universe of features promising greater user-friendliness. However, according to Herbert Koelman, lack of understanding about users' needs means that some cause them to get lost in space rather than find their way to the optimal design

Reports on Computer-Aided Ship Design (CASD) software in this journal tend to lead to a waterfall of the latest features and gadgets of a particular software package, I have also been guilty of this in the past, and I will be in the future. However, in this article I take a bit of a different stance, by focussing on user-friendliness of software in practice. The first issue to address is software features which are assumedly added to enhance user-friendliness, but are without added value in the daily use of the software.

An example of such a feature was the introduction of animated characters named Clippy, Bob and Rover, in the Operating System and application software of a well-known software house. They were introduced to function as an assistant for the novice; however, their performance in that respect was poor, while their appearance was an insult to the professional. After a few years Rover walked away, never to be heard of again. Remarkably, each time such a feature was introduced and discarded, it was lauded as improvement.

This story illustrates that visual appearance offers no added value of its own accord, and neither does flip-flopping with features. Although no CASD software yet exists with cartoon character Flipper or Seal, it is still important to distinguish between appearance and user-friendliness, for the first does not necessarily invoke the latter.

A second pitfall in the quest for user-friendliness is the extension of software with too many specific functions. Although each function might fulfil a particular need, their plurality makes the software as a whole overwhelming, while the distinction between essentials and auxiliaries is not clear. So, the task here is to make functions as generic as possible.

I remember a case, more than 20 years back, where in the same week two client requests came on our (then) new ship hull modelling software. One was on the automatic generation of deck camber, with a constant ratio to the local deck's breadth at side, and the other concerned a feature to generate a shear strake in the hull, at a constant distance from the deck at the side. We could have extended our software with two such generation functions; however, how many more similar, but different in detail, generation function requests would appear going forwards? Without careful consideration, the software would end up with dozens of homomorphic functions. Looking from a distance, the two requests are actually the same, because they both express the desire to let the shape of a curve of the ship hull be dependent from another curve. A dependency editor was implemented which allowed both features to be addressed with the same function – and many, many more shape dependencies with a similar nature.

SARC founder Herbert Koelman

A third observation is that poor software design cannot be repaired by fancy menus or forms. We once had a software function that was configured with a plain old text file. Granted, a bit of an 80s solution, but not harmful, because it was only intended for internal use in the company. The structure of the configuration data wasn't very coherent either, but presented no problem for the same reason as above. When an external party showed interest in this function, interactive menus were created to enter the configuration data. Fortunately, just in time, we realised that although the visual appearance and the operation had changed, the underlying poor design had not. It was a typical example of mission creep, where software is taken from one environment to the other without reconsidering its design. Our customer was therefore told to wait for a better design to be developed.

Root cause analysis

The question to be asked is which mechanisms have led to instances of ill-designed software. We could blame the system developers; however, in general, they are expected to create what the market requests. And the market is the common denominator of the users – ship designers. So, we should look at market focus.

The first issue is what I would call the syndrome of 'electronic availability', that is, the idea that because data are present inside a computer, they can seamlessly be utilised by other software. This idea is maintained by colourful leaflets of CAD software vendors that place the system in the centre, orbited by specialised software systems which communicate flawlessly with the core by means of mysterious acronyms such as STEP or IGES. In general, this is fiction, which users appear to believe without question.

A second phenomenon is that users have become used to the modelling methods or *modi operandi* of existing software. Some methods are so ubiquitous that people come to believe that these are the only methods to use. This mechanism can also be witnessed in the case of youngsters who have grown up with Windows' 'desktop' metaphor and its implementation in File Explorer, which

makes them really believe that digital computers should work in this fashion, and that no alternative exists.

This is a belief that hampers innovation. In effect, users are willing to accept a system as it is, working around its impracticalities. A shining example is from some decades back, when our company prepared stability software for a pre-designed multihull. The outer hulls of the ship were composed of surfaces which were either fully flat, or circular-conical, which struck us a bit odd, for we had expected some kind of foil shape instead for a better hydrodynamic performance. Years later we came to find out that the ship was designed with software which was only fit for monohulls, although additional side hulls could be modelled by means of 'appendages', which were limited to flat or conical surfaces. As such, the shape of a real ship was adapted towards the limitations of the applied software.

Was this a result of long-since abandoned past behaviours? No, because today we also see many hull shapes designed with the popular NURBS-surface method, which is adequate to model regions of the hull but not the hull in its entirety. With commonly used contemporary CASD programs, making intersections between these regions is fairly easy, so that is what designers tend to do, leading to ridges and chines at the intersection of surfaces as a side product. It is astonishing that in 2019 our community is aiming at large-scale reductions of energy consumption, while we accept bad hydrodynamics caused by improper modelling tools.

It is my impression that these examples hint at the root cause, which is a merry-go-round of, on the one hand, users who have learned to utilise what they have, so don't ask for fundamental improvements, and on the other hand, system developers who let themselves be guided by user's demands. Nobody is to blame for this situation; everybody plays his or her expected and accepted role, but the result is suboptimal. Perhaps this vicious circle can be broken if software developers stop listening to their customers?

Pursuit of happiness

To be more precise, the circle may be squared if developers stop taking the customer literally, instead proactively envisioning what the user *really* needs, or will need in the future. Some examples of software developed in this fashion are taken from PIAS:

- Our hull form design method is sculpted to the way a human reasons about the hull, which is with 3D curves on the hull, fixed in an orthogonal plane if required (e.g. waterline, ordinate). 3D surfaces are interactively created between these user-defined curves. Obviously, a computer program based on this method requires many tools and features, but regardless of its implementation and

visual appearance, such a program will be fundamentally user-friendly.

- The way ship designers reason about compartments shows a duality. It can either be viewed from the compartment as such, with its boundaries (or their coordinates) as primary parameters, or from the bulkheads and decks which divide a ship hull into spaces. Our software supports both views, as well as a mixture.
- SOLAS rules for probabilistic damage stability are based on a schematic subdivision model (by so-called 'zones'), which has shown to lead to confusion and inconsistencies, because reality differs from this approximation. Fortunately, the theory of probabilities also allows for a realistic subdivision model, as has been adopted in PIAS, avoiding these inconsistencies. Obviously, to satisfy the occasional classification society that insists on conventionality, a zone-based method is also present.
- Two types of data exchange standards are commonly applied: either canonical, scientifically-based cathedrals of Product Data Technology, such as STEP, or standards that just support the transport of shape, such as DXF, 3D PDF, X3D and JT. The first require a steep and expensive development path, and the second don't contain the constituting components and their functional parameters. Fortunately, there is an alternative where higher-level product elements are exchanged, see [2]. This concept provides a feasible and practical tool for interfacing between heterogeneous software products.

To generalise, user-friendliness can be improved by looking beyond User Interfaces, naval architectural conventions and coincidentally available mathematical methods. It requires a fundamental understanding of the underlying tasks and goals, as well as the preparedness to deviate from convention – but not too much.

Disclaimer

I realise that some of my statements are a bit outspoken. An earlier version of this article was full of relaxations and exceptions; however, in that way it became illegible. So, I saved them to this end: This article draws conclusions, based on general impressions and experiences. The examples are real, however the reference to the different classes of persons – ship designers, software users, software developers – are generalised, with many positive exceptions of persons, programs and companies.

About the author

Herbert Koelman founded SARC in 1980, and is still engaged at SARC as director & principal developer. Since April 2018 he has been part time professor of Maritime Innovative Technologies at MIWB, a bachelor school of maritime operation, engineering and design in the Netherlands. SARC is the supplier of PIAS ship design and LOCOPIAS onboard loading and stability software, www.sarc.nl. *NA*

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From propellers to underwater noise

By anticipating the maritime industry's future problems, HydroComp has managed to successfully negotiate a changing landscape. Its newest initiative focuses on the issue of ship noise pollution

Even for experienced ship designers, coming to grips with propellers and their characteristics can sometimes be a daunting challenge. "It's a very messy physics problem," says Donald MacPherson, technical director, founder and co-owner of US-based software providers and consultants HydroComp.

"There's a lot going on. You can take two ships that are almost identical with two propellers that appear roughly the same. However, someone with a trained critical eye can look at the blade shape and edges, and quickly see the differences. I just happened to have a knack for finding 'the signal in the noise' and to see the whole system come together. From early in my career, as soon as an employer or client learned I was not intimidated by propellers, I became the 'propeller guy' wherever I went."

HydroComp began trading commercially in 1984, initially as a small company that had been subcontracted to provide computer calculations for the shipyard where MacPherson was primarily employed as a naval architect. Gradually, the company became a full-time undertaking and in 1987 it released the first iteration of its NavCad software for speed and power performance analysis. Thirty-two years later it remains HydroComp's flagship product.

At the same time, MacPherson's mastery of the 'black art' of propellers meant he was in growing demand for special consultancy work and these continue to form the two main facets of the business: products and services.

"The split between the two varies from year to year, explains MacPherson. "Under services we include training, consulting and novel research. Right now we're doing a number of projects, including forensic studies for a ferry repower, development of a new surface-piercing propeller performance model for a high-speed craft system simulation, industrial mixer propellers, and a variety of small propulsor units for the submersible community."

In addition to NavCad, the company also has PropCad (for preparation of design drawings and construction data for propellers and thrusters), PropElements (for detailed propeller design) and PropExpert (a propeller selection tool for smaller vessels).

Evolving markets

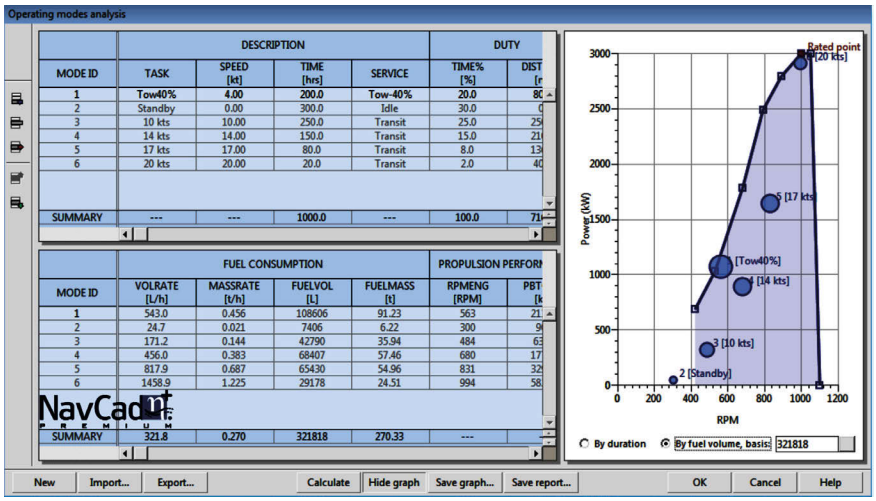
Jill Aaron, HydroComp's managing director and co-founder says the company's customer base has changed in recent years: "It used to be exclusively naval architects and marine engineers. Then our propeller expertise became a valuable asset for an emerging propeller and propulsion equipment manufacturer market. But as we've grown in terms of our product lines, we are now serving so many different interests that it can sometimes be hard to know where to put our energies.

"But naval architects remain our tried-and-true market. Like everyone, we were affected by the decline in offshore oil and gas, but then yachts really took over, and then cruise ships and polar vessels. We are fortunate to have diverse markets, and not to be locked into one particular segment or geographical region."

The challenge, MacPherson admits, for HydroComp and other CAD providers, is how to persuade a very conservative industry to look at the design process differently. Habitually, the option of a diesel engine, shaft drive, gear-box and conventional propellers will always be seen as the safe, risk-free option, with time pressures often leading them to forego exploring the wider possibilities.

"The innovation process is all about idea, research and implementation," says MacPherson. "But while you can point to a lot of research activity, we want to provide that path to innovation with implementation. By that I mean a pipeline to market, which must go through naval architects. At the moment they don't have a convenient way to investigate, say, sail assist or an asymmetric hybrid propulsion system – or any other emerging innovation for that matter – and we hope to address that."

In 2017, HydroComp was heavily involved in the hullform optimisation for an LNG-fuelled ro-pax design. This project, in partnership with Greek engineering company NAP Engineering, was part of the EU-sponsored Poseidon Med II project for shipowner Blue Star Ferries (see *TNA*, January 2018). According to MacPherson it's a pointer to his company's future direction.



More than 30 years after its original launch, NavCad remains HydroComp's most popular offering, but it's just one of a portfolio of products and services

Moreover, with the industry now being forced to wake up to IMO's energy efficiency targets and other emission regulations, and the growing body of opinion that it will be hard to find significant improvements in fuel efficiency with conventional drive systems, for perhaps the first time there's real pressure to find alternative solutions.

Quantifiable pollutants

"It's not just with carbon and sulphur; a few months ago the UN had a meeting about establishing noise as a quantifiable pollutant," notes MacPherson. "This is an important and growing area of research that we hope HydroComp can provide technical leadership as not all approaches to noise mitigation are obvious.

"Some might include strategic decisions that are best served early in the design, such as hull form modifications for improved inflow or even the practical availability and characteristics of a quiet propeller. Others might be operational, such as speed reduction or route changes. Fortunately, all of these could be readily evaluated with the right tools, and we are working on solutions to make that happen for naval architects."

As part of its involvement with the Green Marine, a predominantly North American non-profit organisation that sets voluntary environmental targets for the maritime industry, HydroComp has been heavily involved in an initiative to provide design-side tools to help naval architects effectively mitigate underwater radiated noise (URN). Using NavCad's 'Vessel-Propulsor-Drive' system simulation model, the aim is to address URN problems before the ship hits the water.

MacPherson says that, like propellers, URN is one of those areas of research for which he and HydroComp have a particular passion. "We're working with a university in the UK, and also with a few agencies and design offices in Canada.

"There are ways to assess propeller-driven noise in model tanks and with expensive computational studies, but only the largest shipping companies may have the critical mass to take on such studies, then implement on one ship to see how it goes. Those firms dealing with the remaining 99% of maritime activity currently have no opportunity to do that.

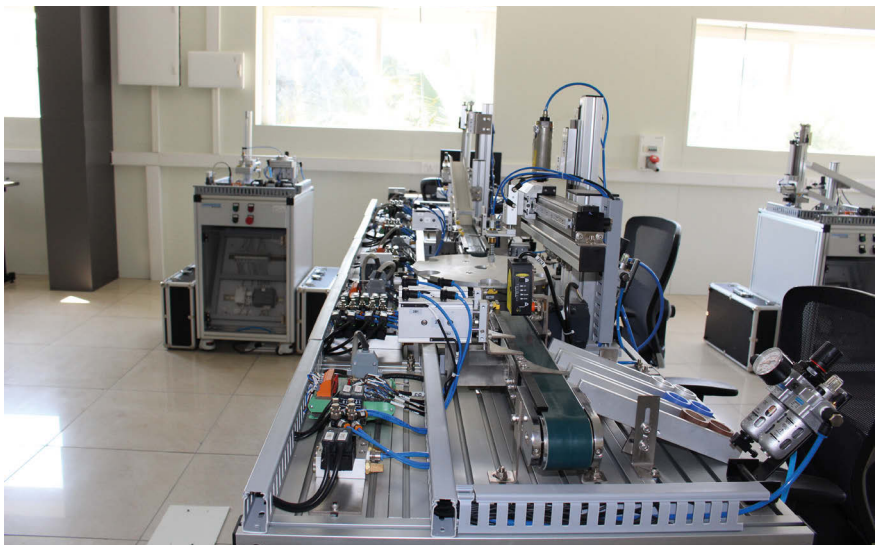
"Naval architects need practical engineering tools to deliver meaningful benefits to their projects and clients. We want to get tools into their hands so they can credibly investigate URN while simultaneously considering how to reduce 'cost of ownership' with new and emerging technologies such as sail assist or energy-saving devices like wake-equalizing ducts. Those are the companies that we look to serve." *NA*

IRClass' Centre of Excellence in Maritime & Shipbuilding

Mr Arun Sharma, Executive Chairman of Indian Register of Shipping, tells *The Naval Architect* about a new initiative to establish India as a maritime educational hub

The Indian Register of Shipping (IRClass) first announced the formation of a 'Centre of Excellence in Maritime and Shipbuilding' (CEMS) in November last year, with a view to meeting the industry's demand to bridge the skills gap and upgrade the expertise of India's maritime and shipbuilding workforce.

One year on, the Centre of Excellence, in association with SagarMala, India's Ministry of Shipping and Siemens, has already made significant progress. CEMS is expected to be officially launched by the Hon. Prime Minister of India, Narendra Modi, in January 2019, with the unveiling of a range of state-of-the-art facilities spread across two strategically placed locations.

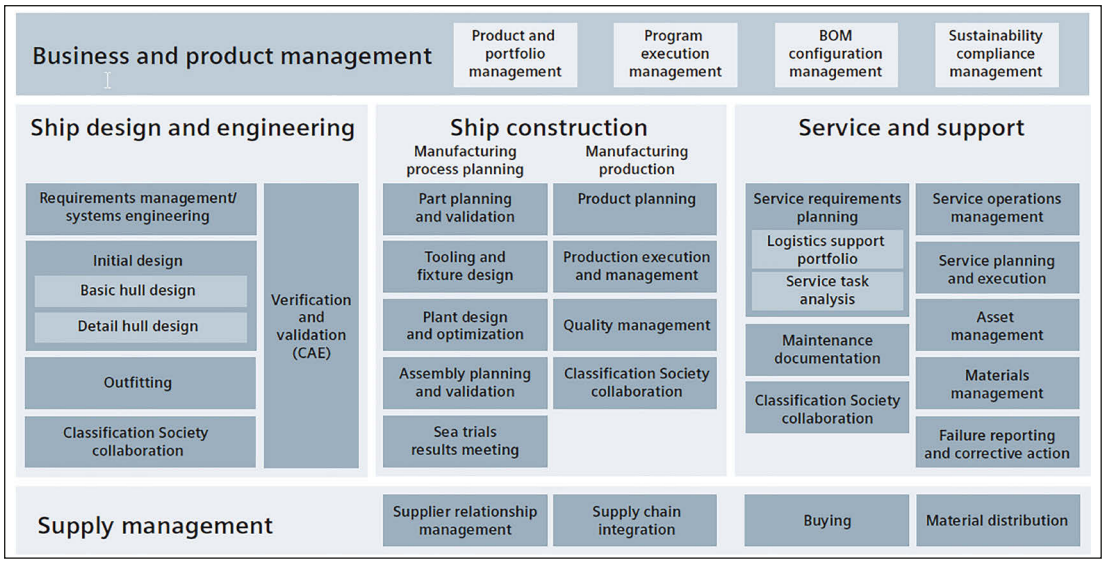


A workstation at the mechatronics lab at Visakhapatnam

Launch of hi-tech labs

The Centre of Excellence has two campuses: one at IRClass's head office in Mumbai, and another situated within the Indian Maritime University (IMU) premises in Visakhapatnam, an important port and a major industrial hub on the east coast of India with several heavy and allied industries, shipyards, and a naval dockyard. Fully equipped with the latest mechatronics and robotics technologies, the Visakhapatnam campus is set to have 18 world-class labs (see Table 1), while the Mumbai Centre will have a further six labs. Infrastructure and facilities for both campuses are already in place and are now awaiting formal commissioning.

The Centre of Excellence provides 50 courses across 18 specialisations and will be covering 770 modules; of these, 270 will be algorithm-based, and the other 500 process and sector-based. With several colleges in the



PLM platforms will be a major focus at the new campuses' development impact area

vicinity, the Centre of Excellence intends to offer its courses for the benefit of students and professionals alike.

Reflecting the growing trend towards process optimisation, particular emphasis will be placed on Product Life Cycle Management (PLM) aspects, starting from ship design to the construction phase as well as lifetime maintenance support of the ship. Towards this end, there will be dedicated courses on a number of iterations of PLM software.

The overall framework of training at the CEMS will create general and specialist competencies in a multitude of areas: ship structure basic and detailed design, ship structure manufacturing, HVAC systems design, multi-discipline validation and simulation, digital shipyard optimisation, shipyard logistics, ship program and product management, hull assembly, supply chain management, 1D and 3D virtual and physical testing, ship building block analysis, nesting productivity improvement, hull design, CNC programming and machining, PLCs, HMI, SCADA, pneumatics and hydraulics, various types of welding technology, robotics, factory concepts like process instrumentation, electrical systems and energy saving methods, use of radar technologies, pump systems and piping systems.

S.no	Laboratories
1	Product Design and Validation Lab
2	Advanced Manufacturing Lab
3	Test and Optimisation Lab
4	Dimensional Accuracy Control System Lab
5	Nesting - Productivity Improvement Lab
6	Hull - Design Lab
7	Research Machine Shop
8	Automation Lab
9	Mecatronics Lab
10	Welding Technology Lab
11	Robotics Lab
12	Process Instrumentation Lab
13	Electrical Lab
14	Pneumatic & Hydraulic Lab
15	Virtual Reality Lab
16	Pumps Training System Lab
17	Piping Training Systems Lab
18	Radar Training Lab

Table 1: The different labs at Visakhapatnam campus

Indian ship design and construction

The Indian shipbuilding industry is of strategic importance to the Indian economy and plays an important role in employment generation, development of manufacturing and related industries, and national security. The Government of India has thus set ambitious plans for the shipbuilding and ship repair industry in the country.

The marine industry worldwide is in transition and undergoing significant transformation, as even European shipbuilders begin to lose their market share to Asian countries. The changing international landscape, where external companies contribute 80% of value to shipbuilders, is increasingly concentrating on design and system integration. Challenges for survival have arisen, involving workforce skills, new design and the need to integrate suppliers and external parties. Consequently, there is increased focus by leading Indian shipyards on improving productivity, aligning operations, and optimising processes.

One of the issues the Centre of Excellence plans to tackle is the shortfall in the design of commercial ships in India for seagoing, coastal and inland waterways operation. Via the Centre of Excellence, Indian shipyards will be able to gain access to basic as well as detailed working designs for the production of vessels that are more relevant to today's market requirements. In addition, a study is planned to better understand market needs.

Skill development in the coastal region

Coastal economic development stands as one of the most important objectives. This will pave the way for societal development and livelihood creation through the cration of port-led ecosystems, developing industrial clusters through anchor manufacturing industries and most of all creating jobs through encouragement of entrepreneurship.

The creation of a conducive environment for industrial clusters and anchor industries to grow is very important to achieve the goals set forth. A holistic skill development framework executed to reach the corners of the coastal economic regions becomes imminent to leverage the huge economic multipliers of ports, focus on early job creation and most of all minimise the time taken to realise economic benefits.

Such a skill development infrastructure would serve multiple purposes, namely to create a pre-fabricated ecosystem for investments in the coastal areas, bridge the skill gap of Rs2.84 Crore (US$40 million) manpower required in the coastal states over various sectors and most of all, create livelihoods in the influence areas.

Socio-economic impact

The capacity of infrastructure of CEMS will be 10,512 trainees in one year. This holds immense potential for the country, the industry and people in coastal economic zones to up-skill and re-skill themselves at highly subsidised rates in relevant marketable technology for employment in shipbuilding and related industries. Skill development at CEMS will take the trainees to world class level in not only design but also in the manufacturing sector.

The international accreditation of courses offered in the Centre of Excellence would equip the students and working professionals with an opportunity to work in global shipbuilding and allied sectors. *NA*

Indian shipbuilding ambitions struggle to make progress

The Modi government's target of doubling the output of Indian shipyards by 2022 will be difficult, says the Shipyards Association of India

With a coastline of 7,000km, 14,500km of navigable waterways, and 12 major ports, the story of Indian maritime has long been one of unfulfilled potential. Most estimates put India's contribution to world trade through shipping in the region of 7-8%, but as a shipbuilding nation it has long lagged behind the powerhouse nations of East Asia.

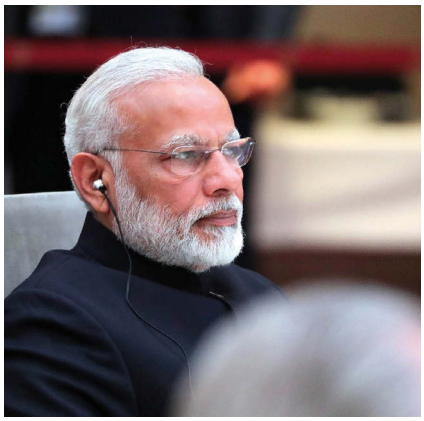
According to P.R. Govil, advisor and spokesman for the Shipyards Association of India, this is not for want of expertise: "Indian shipyards have the capability to build a variety of ships up to 350,000dwt, ranging from Panamaxes, tankers, LNG carriers, passenger, defence, patrol and offshore.

"The strengths of Indian yards are the availability of skilled manpower and low labour costs. The weaknesses are the high cost of financing and the lack of a ship ancillary industry [materials and equipment providers] in India."

In the pre-crash era of 2002-2007, with the help of a government subsidy programme, India accounted for 1.24% of global shipbuilding orders, according to figures published by India's Shipping Ministry. However, the end of this scheme, coinciding with the 2008 financial crash, saw production plummet to just 0.01% by 2012. Since the recession, Govil says, Indian shipbuilding has largely survived on naval and defence contracts. Of the 27 shipyards in India, seven are state-owned and focused on the defence sector.

Made in India

Renewed impetus came in 2014 when, as part of his larger 'Made in India' initiative, Prime Minister Narendra Modi announced ambitious plans for the Indian maritime sector, including the 10-year Shipbuilding Financial Assistance Policy (SFAP). Under the SFAP, formally launched in 2016, shipyards receive up to 20% of the cost of a ship, irrespective of its size or type, upon construction and delivery of the vessel. Unfortunately, says Govil, the policy has made little impression in reversing the prolonged downturn and Indian yards are still struggling to win orders.



Narendra Modi

An additional policy, tentatively announced by the government in 2017, set forward a strategy that would have doubled India's shipbuilding capacity and seen increased focus on niche shipbuilding capacity, with the aim of positioning India as a hub for LPG, LNG, cruise and chemical tanker production. The groundwork had been laid two years earlier, when the state-run Cochin shipyard signed a collaboration agreement with Samsung Heavy Industries (SHI) of South Korea, which would have seen Cochin workers trained in LNG shipbuilding techniques.

However, the plans were contingent upon the requirements of GAIL (India) Ltd, the state-run gas firm, which had indicated it needed up to nine new vessels for the export of gas from the US. When GAIL subsequently determined it was more cost effective to source its gas from elsewhere, and delegate transportation of the gas to those suppliers, the Cochin/SHI arrangement no longer served a purpose.

"In my personal opinion it may be difficult to double the size of shipbuilding industry in India by 2022 unless the position improves," laments Govil.

Silver lining?

Yet, as the opening of the Centre of Excellence in Maritime and Shipbuilding (see p.28-29) demonstrates, it's by no means all doom and gloom for the Indian maritime sector, even if it may take some years to start reaping the rewards. Moreover, India has no shortage of expertise in marine engineering and ship design. Putting forward the naval architect's perspective, Pratibha Sawant, CFO for Indian-based Buoyancy Consultants, stresses that shipping is ultimately a global industry: "As design engineers, we have no limitations as we are location neutral. India still accounts for about 3% of our total revenue. While the number of design firms registered here is about eight in all, the majority of their clients are overseas. The sheer volume of work and cost economics from more mature markets are as-yet unparalleled," says Sawant.

"Furthermore, specialised analyses like harmonic studies have no takers for the Indian market."

Sawant points to the Sagarmala Project, the government's US$120 billion initiative to unlock the potential of India's inland waterways through new ports and coastal communities, as a major source of encouragement. In addition, there are the opportunities afforded by the Ballast Water Management Convention and 2020 sulphur cap. "Given that yards are being booked across the globe will lead operators to carry out retrofits in India over the next three quarters," he notes.

Not, perhaps, the great step forward envisaged by Modi, but a glimmer of hope for the future. *NA*

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Methanol as a marine fuel: the shipyard perspective

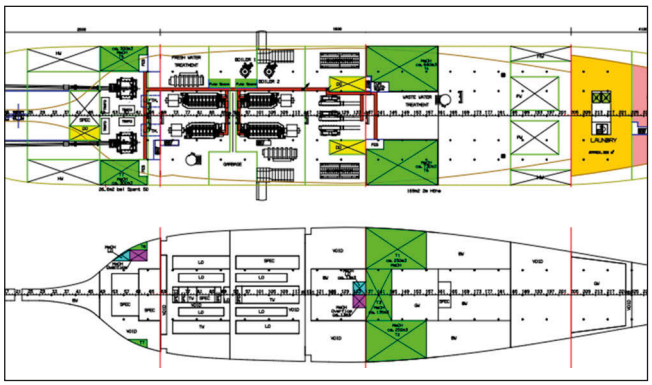
MethaShip project leader Daniel Sahnen highlights the practical and environmental advantages of methanol as fuel, and considers the legislative and production steps required to render it a viable alternative for vessels evaluating their future fuel choices

What are the options for future marine fuels that enable the shipping industry to enjoy sustainable operations while cutting carbon emissions and minimising risk to the marine environment? That was the question considered by the MethaShip project in the four years between 2014 and 2018.

Its findings suggest that the solution to the industry's problem of cleaner fuel that can be adopted at reasonable investment, requiring little additional training and is safer and simpler to use than current alternatives, already lies within its grasp.

MethaShip is a nationally funded German research project whose partners include Meyer Werft, Flensburger Schiffbau-Gesellschaft, and classification society Lloyd's Register; associated partners include Methanol trading company HELM and OEMs Caterpillar and MAN Augsburg. Its chief aim is to examine the use and suitability of methanol as a fuel for cruise ships andro-pax ferries.

The drivers are the same as those which saw Meyer Werft deliver its first fully LNG-powered cruise ship *AIDAnova* in autumn 2018. Pressure is mounting to increase the use of cleaner fuels in shipping and especially in the cruise sector; growing environmental impact awareness among passengers means alternatives to conventional fuels are needed.



Exemplary tank arrangement showing seven tanks

Considering the alternatives

Without question, the design, construction and delivery of *AIDAnova* was a milestone for the cruise industry and for Meyer Werft so as to allow the use of LNG to deliver reduced pollutant emissions. However, the project also highlighted practical issues that come with LNG systems on board of ships such as sophisticated tank systems, space requirements and expensive component technology. Further, methane's greenhouse gas relevance to emissions along the well-to-wake chain will certainly become an issue of future considerations.

This background prompted the German shipbuilders to consider what other fuels with clean properties could be employed and brought methyl/ethyl alcohols into the conversation. As a result the MethaShip project was founded with the aim to evaluating methanol both in terms of suitability for vessel application and sustainability aspects. The project was also designed to make a positive contribution towards the continuing rule development process at IMO concerning the adoption of methyl/ethyl alcohol fuels into the IGF Code.

Work packages for the project included an assessment of fuel infrastructure, ship systems and energy converter technology, utilisation of thermal energy, development and design, rules and safety and eco-balance and lifecycle assessment.

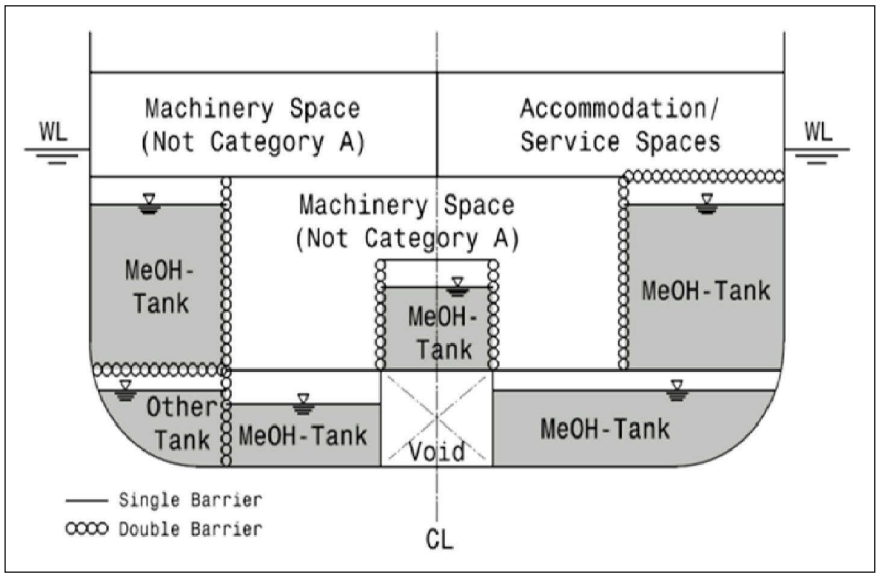
The project focused principally on two methanol ship designs. Firstly, a ro-pax ferry 200m in length, 29m wide with a passenger capacity of 600, and second, a cruise ship of 240m and 63,000 GT, for 2,100 passengers, driven by two power plants each with two 9MW engines running mainly on methanol.

The methanol fuel tanks were positioned amidships and aftships, situated at the side of the vessel's hull allowing for free inner space between them. The ship was designed with a total of seven fuel storage tanks with the two aft designed to fulfil IMO safe return to port requirements.

Because methanol can be stored at ambient temperature and pressure, it allows for a conventional coated mild steel tank configuration in the ship's double bottom, with secondary barriers as liquid leak protection or single walled barriers depending on adjacent internal spaces. The very good environmental properties of methanol allow the storage directly at the ship's shell and inside the double bottom; an advantage compared to the storage of diesel fuel.

Contributing to rule development

The project thoroughly considered the behaviour of methanol in fuel tanks. At the atmospheric storage pressure of



IMO Rule Recommendation for fuel tank arrangement showing the application of secondary barriers

1 bar and a temperature of the liquid phase of 20°C, the maximum methanol concentration in the gaseous phase present could never get higher than 13%.

Unlike LNG, with temperature increase, methanol does not boil but instead follows a slow evaporation process with a little higher concentration of MeOH in the gaseous phase. For instance the maximum gas concentration at 30°C would be 22% and can physically go no higher. So even in case of a little tank breathing pure methanol vapour would never occur but instead a mixture with the nitrogen inert gas.

The second crucial difference between gas and liquid fuel systems is the behaviour in case of a leakage. In case of a rupture in a single-walled gas leading pipe, gas has the ability to fill the entire surrounding space. In the case of a liquid fuel even with immediate pressure release, there is generally smaller loss of liquid which can be easily detected, contained and mitigated by ventilation or diversion. Detection of a methanol spill is already possible from two parts per million upwards – in order to be explosive it must be 55,000ppm.

The results of this work formed the basis of two contributions to the IMO rule development process, with submissions made to the Sub-Committee on Carriage of Cargoes and Containers (CCC) in 2016 and 2017, on system and ship design and the barrier concepts.

The submissions also covered the arrangement of ancillary machinery spaces including pumps and valves as well as venting, manhole access and fire safety. The project found the methanol fuel system equipment can be safely positioned in a ventilated space without an additional airlock, simplifying the layout design with easier arrangement of vent outlets and smaller hazardous zones.

Clearing up misconceptions

The MethaShip project concluded that, judged simply by its physical characteristics, methanol is superior to any fuel that is not naturally liquid. However, despite its many operational and environmental advantages, methanol continues to be the subject of many myths and misconceptions around its use in practice.

While every fuel has inherent hazards, from an examination of Hazard and Precautionary Statements which describe chemical hazards and give advice for the safe handling, it is clear that methanol is no more dangerous than other fuels.

The US EPA has examined methanol in the context of automotive fuel and highlighted significant advantages compared to gasoline. Its lower volatility means it does not emit vapour as easily as gasoline. It has higher flammability requirements – it must be four times more concentrated in air for ignition to occur. It also has lower vapour density, very similar to air, so instead of travelling along the ground to ignition sources, it will tend to disperse more rapidly with air and fast dilute to non-ignitable concentrations.

Because methanol has a lower heat release rate, it burns 75% more slowly than gasoline or diesel in case of fire. The EPA concludes that casualties from auto fires would drop dramatically if methanol were used as the country's primary automotive fuel.

In a case of poisoning reported in the Journal of Occupational Medicine a consultant supervising tank cleaning was affected because he was wearing the wrong protective clothing. After two to three hours in a confirmed space his clothes were soaked in methanol and eight hours later he showed symptoms of acute viral toxicity.

However, with the appropriate treatment, using ethanol from the ship's bond administered in hospital, he made a full recovery. Exposure to methanol is highly unlikely due to the double barrier applied in the ship designs.

The environmental advantages

Methanol also displays highly positive environmental properties in terms of spill risk and its potential effect on the environment. Not only is methanol significantly less toxic to marine life than fuel oil, its effects in case of a spill are nearly negligible, and if, only temporary and reversible.

For example the lethal concentration in water for fish (LC50, at which half the populations dies within a specified test duration) of diesel is just 65mg per litre of water and 70mg/l for HFO, compared to 15,400mg/l for methanol. The effect on algae of conventional fossil fuels is if anything worse, diesel being 78mg/l but HFO being 1mg/l while the effect concentration (EC50) of methanol is 22,000mg/l.

A simulated release of 10,000tonnes of methanol in the open sea showed a concentration of just 0.36% after one

hour. In another simulation releasing 10,000 litres per hour from a coastal pier found that methanol would have a concentration of less than 1% after two hours and of 0.13% after three hours.

By comparison the release of 13,500 tonnes of heavy fuel oil from the tanker *Erika* affected 400km of coastline and caused total damage and clean-up costs approaching US$1 billion. It can be concluded that such an accident with methanol would have had nearly no impact on the environment with zero clean-up costs, since methanol rapidly mixes with water, dilutes far below critical levels and is completely biodegraded by bacteria and waterborne organisms.

The major challenge for methanol is whether it can be used as a sustainable fuel to help the shipping industry meet the reductions required for compliance with IMO targets for greenhouse gas reductions till 2050 and beyond.

When we look at how the majority of methanPol has been produced until now, in lifecycle terms it still has a significant GHG emissions profile. What MethaShip concluded is that methanol produced from renewable sources would probably quickly become the e-fuel of choice for the maritime industry.

Biomethanol can be produced renewably from landfill gas, biomass, or by utilising CO_2 point sources. In particular the long-run path of extracting CO_2 from the atmosphere using Direct Air Capture technology has been evaluated quantitatively. Such a carbon source, combined with hydrogen from electrolysis, fed into a methanol synthesis reactor provides a net-zero carbon fuel from well-to-wake.

Demonstration plants are already producing low-carbon methanol through a carbon capture/re-injection production loop. Methanol production offers a wide range of feedstock and process technologies for 'future proof', net-zero carbon marine fuels.

Methanol moves ahead

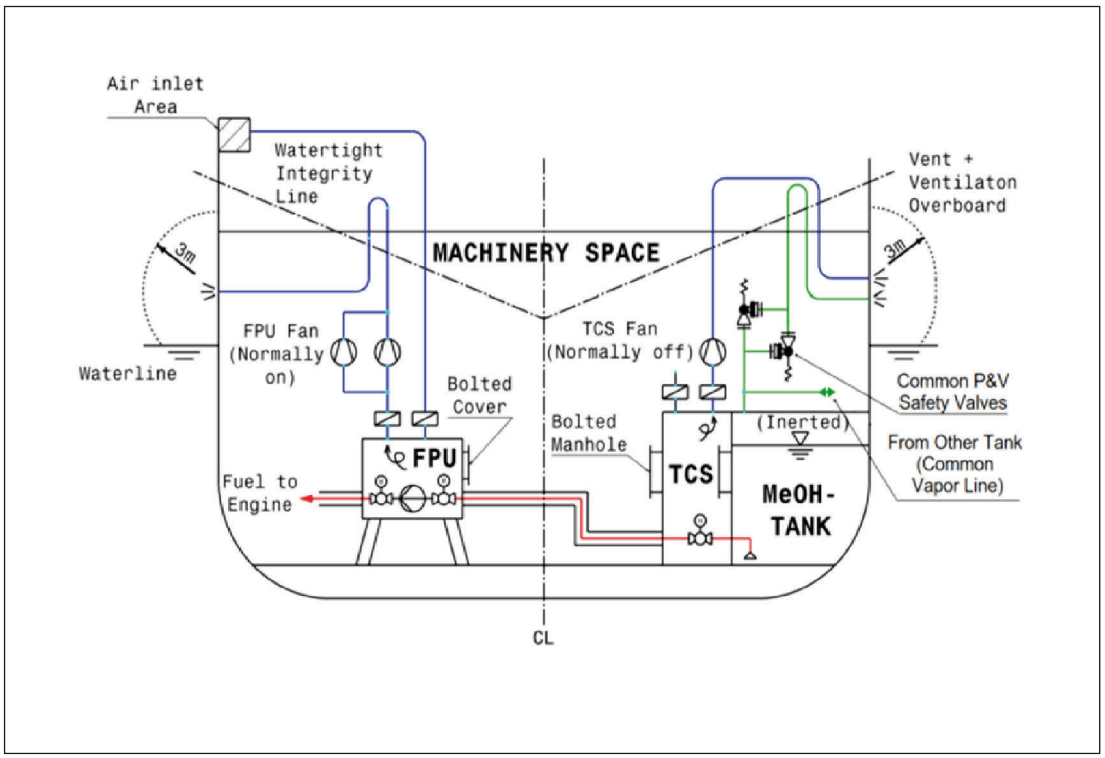
When considering the introduction of lower emission fuels, both the cost of infrastructure development and supporting regulation will play a major role in their adoption.

The completion in September by the IMO's CCC5 sub-committee of draft interim guidelines covering the safety of ships using methyl/ethyl alcohol as fuel are a further promising step towards goal based rules for methanol that utilise its inherent advantages.

The ultimate aim will be to add a new chapter on methyl/ethyl alcohols to the IGF Code with draft interim guidelines finalised urgently and a commitment to add a new section to the IGF Code as soon as possible. This follows the decision taken by IMO to invite the International Organisation for Standardisation (ISO) to develop a standard for methyl/ethyl alcohol as a marine fuel and a standard for methyl/ethyl alcohol fuel couplings.

In contrast to LNG, methanol requires much lower investment in terms of bunker supply infrastructure, since it is already available at major ports – and certainly those used for marine bunkering. Existing onshore and bunker vessel infrastructure can easily be adapted and deployed to supply methanol and in Europe, a fleet of inland waterway vessels already carrying methanol as chemical products could service much of this demand.

For installation on newbuildings or retrofit conversions, methanol has clear advantages compared to LNG, requiring simple non-cryogenic tanking and liquid fuel delivery system. The methanol-fuelled ships already in service have proven the concept and wider adoption is possible. *NA*



IMO Rule Recommendation for vent and ventilation arrangement

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E(co)- navigation

The green benefits of instant information exchange were in the foreground at the final conference of the STM Validation Project

With the constant flow of new technologies and innovations across the maritime sector it can sometimes feel as if the more prosaic requirements of how the ships of the future will actually communicate with each other and operate in common seaways are merely incidental. Moreover, how much does the wider industry benefit from the safer, greener and more efficient practices of a few pacesetters if there's no infrastructure for exchanging information for the greater good?

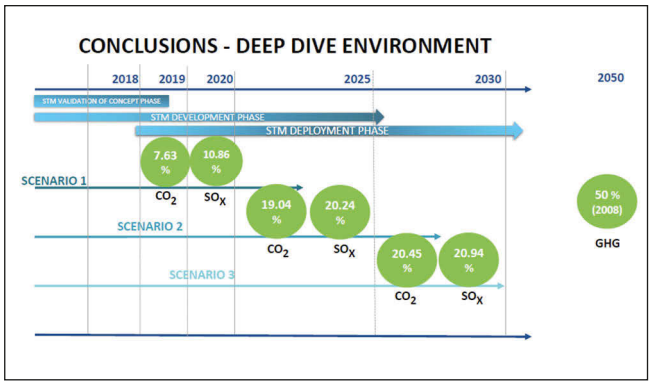


Fig 1. Even with current ship technology, emission savings of more than a fifth are achievable with port call synchronisation and optimisation Source: STM Validation Project

Back in 2011, Captain Fredrik Karlsson and Master Pilot Ulf Svedberg of the Swedish Maritime Administration (SMA) had the brainchild of adapting the model of Air Traffic Management to commercial shipping. The SMA had previous experience where such innovations were concerned; during the 1990's it had been heavily involved in the development of AIS (Automated Identification System), the VHF transponder-based vessel tracking system which IMO made mandatory for ships of 300 tonnes and over from 2001.

Before very long the idea of Sea Traffic Management (STM) began to gain traction. Between 2013 and 2015, STM was refined under the auspices of the MONALISA 2.0 project, with its Route Exchange Format (RTZ) receiving the approval of the Electronic Technical Commission (IEC) in August 2015. This in turn led to the STM Validation Project, a EUR43 million initiative described as the biggest civil e-navigation project ever undertaken.

As its name suggests, the purpose was to validate the STM concept and services with 'test beds' involving some 300 ships, 13 ports, 13 simulation centres and five shore centres. In November, IMO headquarters in London hosted the STM Validation Project's final conference, which presented some of the findings of these trials.

The event was opened by IMO Secretary General Kitack Lim, who expressed his own personal support to STM while encouraging the project leaders to submit the results to IMO at the earliest opportunity. Lim noted that many of STM's goals are intrinsically linked to those of IMO, pointing in particular to the organisation's e-Navigation Strategy Implementation Plan (SIP) for drawing up a regulatory framework for new technologies.

The principles of STM

Essentially, the principles behind STM are relatively straightforward. Each STM-enabled vessel can choose to share the next seven legs of its voyage plan via its AIS, which can then be displayed on the navigation systems of other STM-enabled ships.

Ship-to-shore data exchange works slightly differently, with the information sent in IP-format across any communication channel, but kept secure by the service and identity registries of the Maritime Connectivity Platform (MCP), an open-source platform STM has been involved in the development of. The information owner (i.e. the ship or shipowner) would select the partners with whom it wishes to share details relating to its voyage.

If, for example, the vessel was travelling from Singapore to Sweden via the Suez Canal, and wanted to arrive for just-in-time passage, it could choose to share its voyage plan with the Suez Canal Authority. Likewise, its journey up through the Mediterranean and North Sea would involve negotiating a number of buy seaways and mandatory Ship Reporting Systems (SRS) en route, where it might send its voyage information to get feedback on possible congestion. Finally, it would share with the port authorities in Sweden so that preparations for its arrival were adjusted accordingly.

In most cases, the only requirement for ships to participate will be an up-to-date version of its Electronic Chart Display and Information System (ECDIS), which is mandatory navigational equipment for most larger commercial vessels. In terms of the wider range of STM functions, it's likely that the platform will ultimately support a range of free and commercial services, the advantage of a standardised open-source platform being that it will lead to higher competition. The establishment of a common language is also considered a prerequisite in the rollout of autonomous ships, given that each ship will need to communicate its intentions to others in its vicinity.

Emissions benefits

Greener shipping has been at the heart of the project since it beginning. Real-time data exchange empowers services such as route optimisation, ship-to-ship information, enhanced monitoring (e.g. for emissions) and port-call synchronisation. These in turn facilitate more just-in-time arrivals and allow vessels to adjust their speed accordingly,

rather than arrive at their prescribed destinations only to find they have to have to wait for a berth.

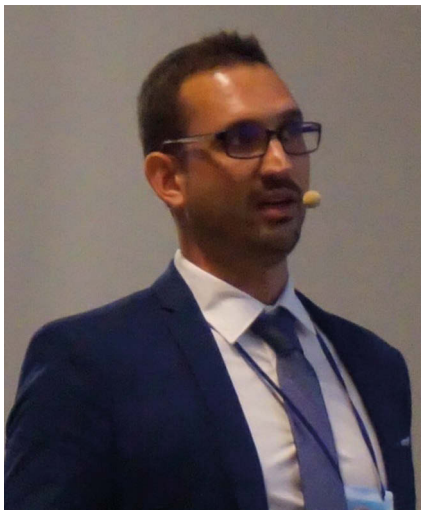
The EU's investment is tied to its 'Motorways of the Sea' initiative to promote greener sea-based transportation links, with goals including a 10% reduction of voyage costs (including 30% reduction in berthing waiting time) and 7% lower fuel consumption by 2030. But there's also a strong safety element; by improving the efficiency and communication of ships navigating European seaways it is hoped it will be possible to halve the number of accidents.

The STM Validation final conference included a 'deep dive' into the environmental issues. Drawing from IMO's GHG strategy, and its targets of a 50% reduction by 2050, José Andrés Giménez Maldonado, energy and safety director at the Valenciaport Foundation, scrutinised the benefits in terms of fuel consumption and greenhouse gas emissions.

"It's all about changing the view that we'll solve the problem with LNG or when ships are electric," he explained. "The main strength of STM is we can start saving on emissions today, we don't need to wait for a brand new fleet."

To demonstrate the benefits of STM-enhanced operational efficiency, Maldonado and his research team needed to develop and validate a method for calculating fuel consumption and emissions. To achieve this, AIS reported data was collected for 36 of the STM test vessels over a period from June 2017 to May 2018. The range of vessels analysed included containerships, tankers, car carriers, general cargo and ro-paxes. Importantly, each route was completely unique as it was derived from real information.

Tailor-made scripts were written to process this AIS data, reflecting variables such as distances, turnaround times and navigation phases. The researchers then applied the 'ICCT Methodology' (used by the International Council on Clean Transportation for its 2017 study 'Greenhouse gas emissions from global shipping 2013-2015'). At the end of this process the team had achieved results for navigation and port operations times, estimates of fuel consumption and estimates of GHG emissions.



José Andrés Giménez Maldonado, Valenciaport Foundation

However, to verify the model it was still necessary to compare the figures with the real world. The team visited one of the STM test ships, the ro-pax *Stena Scandinavica*, and met the crew. "When we showed them the fuel consumption figures they asked us who had given us this data. They were very surprised by the accuracy of the numbers, which gave us confidence," said Maldonado.

This model was subsequently applied to three scenarios for 'just in time' arrivals, which the team identified as a major area for gains (see Fig. 1). The first of these considered the impact of port call synchronisation in the early stages of STM implementation and determined there would already be appreciable benefits in terms of emissions benefits.

The second scenario hypothesised on the even greater savings of 'full' port call synchronisation, as well as an 'early' stage of port call optimisation in which other portside tasks are processed with increased efficiency. Now it was calculated the emissions savings would be more than doubled.

A third scenario calculated there would be additional, albeit minor, savings if both synchronisation and optimisation reached their 'full stage'. Maldonado explained, however, that these were deliberately conservative. "We need more data and information from the ports about why they can't do more to help before we can make any bigger assumptions."

These findings, he also stressed, are only an average based on the sampled test ships, with some ship types subject to great efficiency improvements than others. "With containers we would be in the range of 30% savings," he said.

"The main strength of STM is that it can allow us to start saving on emissions now. We don't need to wait for complete transformation of the fleet and maturity of new technologies. Maybe with this shared vision of operational efficiency we will be able to reach the ambitious 50% reduction goals."

"We believe that if we deploy a suitable digital environment to allow actors to exchange information we are surpassing at least one barrier and maybe that will act as a driver for transformation. Many other businesses have been transformed by digital solutions, so why not shipping?"

The future

While the STM Validation phase is now complete the event also saw the announcement that nine of the project's industry partners – Airbus, Chartworld, Furuno, Kongsberg, SAAB, Sperry Marine, Wärtsilä, Vissim and Combitech – have agreed to 'take ownership' of the platform and work together in continuing its commercial development in hardware and software solutions so that it can viably adopted as a standard.

Meanwhile, trade association BIMCO has also announced the introduction of the Sea Traffic Management Clause for Voyage Charter Parties. BIMCO had recognised that a potential conflict arises between economic and environmental efficiency because of the way risks are allocated in the charter parties, and says the clause will assist the charterer and shipowner on how to split benefits coming from optimised speed when port calls are better synched.

Grant Hunter, BIMCO's head of contracts and clauses, said: "The environmental aspects of shipping become more and more relevant for the actors in the industry. This will affect the operational mindset of us all. The IMO climate goal is helping to push us in that direction."

Global implementation in 2030 may be some time away, but don't expect STM to slip into the sunset. ***NA***

Selecting a safe ice class for ships

Through independent analysis of full-scale data, Aalto University's Pentti Kujala determines whether each ice class' parameters as set out in the Polar Code reflect the reality of safe vessel operation when assisted by an icebreaker

Selection of a suitable ice class for ship operation is an important, but not simple, task. The increased exploitation of polar waters, as well as the introduction of new international design standards such as Polar Code, reduces the relevancy of using existing experience as a basis for the selection. New methods must therefore be developed.

Historically, since the mid 1990's, Canadian ice class rules known as CASPPR (Canadian Arctic Shipping Pollution Prevention) have been based on analysis of the navigation sea area and time of the year to determine the required ice class. Russian Register started to use a similar approach about 10 years ago. The challenge this approach faces is that it is based on the practical experience of ice navigation but does not take into account changing ice conditions due to climate change.

IMO has since adopted the Polar Code and related amendments to make it mandatory under both SOLAS and MARPOL. One aspect of the Polar Code addresses the operational limitations of ships of different categories (A, B and C) according to the prevailing ice conditions.

The approach for evaluating the ice conditions and setting limitations for ships assigned an ice class is called POLARIS (Polar Operational Limit Assessment Risk Indexing System), details of which are given in an IMO amendment document (MSC94, 2014). Therein the ice classes are associated with the limiting thickness by combining the experience from three existing approaches used in ice-covered waters: the Canadian Arctic, Baltic (Finnish/Swedish), and Russian Northern.

As stated in Table 1, MSC94 categorizes ships designed according to Finnish/Swedish Ice Class Rules (FSICR) for different operational conditions; 'assisted' operation corresponds to scenario where icebreaker assistance is provided or the ice concentration is less than 100%. The numbers given in Table 1 are based on past experience and represent the first time the limiting ice thicknesses have been clearly stated.

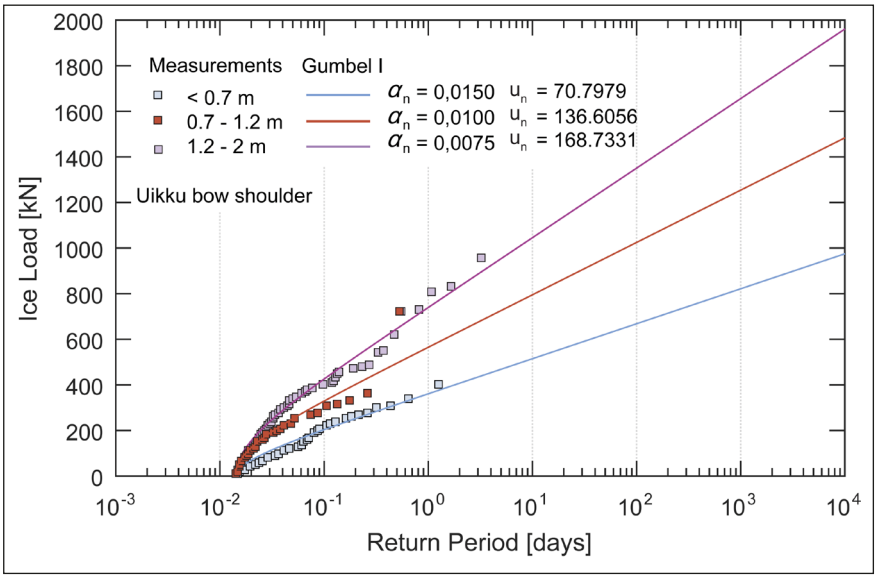


Figure 1. *MT Uikku* bow shoulder measurements fitted with Gumbel distribution

In a recent paper (Kujala et al., 2017), a validation of these numbers is conducted through systematic comparison of the measured ice load with the limiting strength of the ice-strengthened structures.

The ice load in various conditions is determined using the ARCDEV data from the winter of 1998 onboard *MT Uikku* (Murmansk-Ob Bay) as the basic database. The database includes 3-weeks of ice load measurements during April 1998 on the Kara Sea mainly with icebreaker assistance. Gumbel type 1 distribution is fitted on the measured 20 min maximum values and the data is divided into various classes using ship speed, ice thickness and ice concentration as the main parameters. The sea ice thickness varied on the voyage from 40-120cm. Figure 1 gives as an example the Gumbel type 1 distribution fitted on the measured data at the bow shoulder area.

By comparing the measured load in various ice conditions with the serviceability limit state of structures, limiting ice thickness for various ice classes can be determined. *MT Uikku* is here used as the reference ship, with the hull structures re-designed to achieve three ice classes for the vessel according to FSICR notation: IA Super, IA and IB. The limit for these designs is determined using numerical finite element simulations whereby permanent deformations of structures are established along with the corresponding load level required to achieve them. The permanent deformations comply with DNV serviceability limit state of s/12 used by surveyors.

It is important to highlight the fact that *Uikku* has a multifunctional icebreaking hull form which possibly decreases the measured loads. Nevertheless, results can be generalised to blunt hull forms as the largest measured loads are measured on the shoulder area, where the frame angle is not substantially different between a multifunctional icebreaking hull and blunt hull.

For the selected structure, because long-term measured data in different ice thicknesses is available, it is possible

Ice class	WMO description of the ice regime	Thickness of ice floes, h_i
IA Super	Medium first-year ice	h_i up to about 100cm
IA	Medium first-year ice	h_i up to about 80cm
IB	Thin first-year ice	h_i up to about 60cm
IC	Thin first-year ice	h_i up to about 40cm

Table 1. Safe operation of ships in first-year winter ice regime for the Finnish-Swedish ice classes for ships assisted by icebreaker (MSC94, 2014)

to associate ice thickness with resulting permanent deformation. The latter association lends itself to explicit definition of limiting ice thickness for safe operation. It is assumed here that the ice class of the ship does not have large influence on the encountered ice loads especially when it navigates behind an icebreaker.

When serviceability is considered a limiting condition for safe operation, results encouragingly show that present designs are safer than assumed in the Polar Code when operating under icebreaker assistance or when ice concentration is less than 100% (we cannot analyse independent navigation as no relevant full scale data is available for that purpose).

The 'extra' safety depends on the ice class, with IA Super showing the largest safety margin i.e. the maximum ice thickness can be up to 2m. For IA the maximum safe ice thickness was found to be 1.2m, i.e. about 50% higher than given in Table 1. When conservatively associating local yield of the hull structures with safe operation, the limiting ice thicknesses provided by POLARIS correlate well with the present findings. This means that following the guidelines given in Table 1, some local yielding can take place on the hull structures with the limiting thickness but the margin for any permanent deformation is still 50-100%; Table 1 thus gives us a safe approach for selecting a proper ice class. *NA*

References

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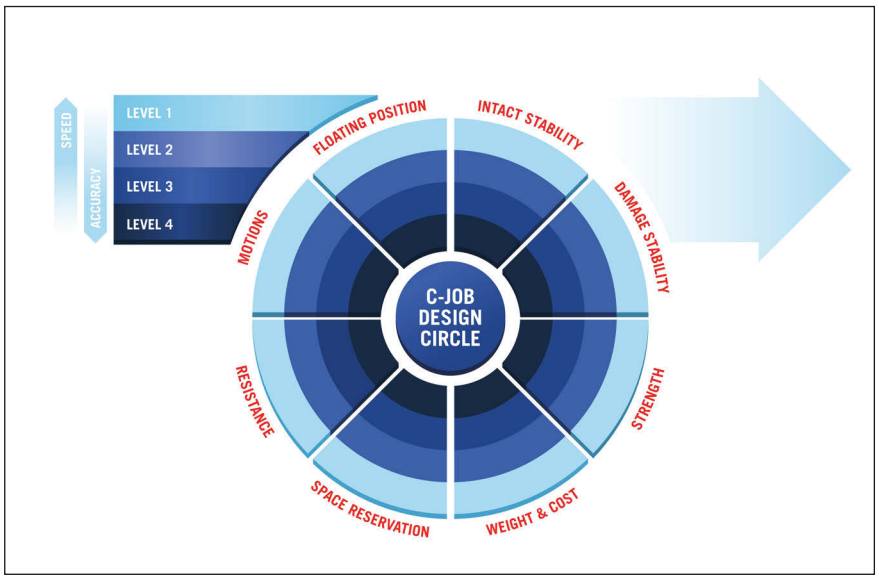
A quizzical response to 'accelerated concept design'

In in his article 'Accelerated Concept Design' in October 2018's edition of TNA (p22-23), Roy de Winter of C-Job Naval Architects argued that greater design automation and detailed naval architectural analysis during the earlier stages of design could optimise and expedite the process. As ship design grows increasingly complex and diverse, Professor David Andrews of University College London is unconvinced this is really desirable.



C-Job's accelerated concept design uses the analogy of a design circle

After some 30 years of design practice on a wide range of naval and auxiliary vessels including the concept design of much of the current RN fleet and, since 2000, the Professor of Engineering Design leading research into the design of complex vessels, I think I have some justification in challenging the consequences behind the implied desirability of 'accelerating' the ship concept design phase, as Roy de Winter proposes.

Accelerating the concept phase is too often seen as desirable to quickly get to "the design solution" with which to then proceed into full design, but this means rushing through this critical first design phase. Such an approach is not generally appropriate because the concept phase is quite unlike the rest of ship design, the reason for which I hope to briefly explain below. In the recently published *Special Edition of RINA's International Journal of Maritime Engineering (IJME)* I address the concept design of complex vessels, based on almost five decades of experience. That paper is entitled "*The Sophistication of Early Stage Design for Complex Vessels*" and brings together various aspects concerning the nature of Concept Design.

It should be emphasised that the term 'complex vessels' in this instance extends well beyond naval combatants and includes more merchant ship like naval auxiliaries, such as fleet tankers, and even a new Royal Yacht design for which I had design responsibility.

The first point I wish to highlight in response to the October article is that a very wide range of design novelty needs to be properly considered when exploring the possible options in meeting a new ship need. Table 1, which is based on a set of examples spelt out in the Special Edition paper, implies that the concept design work when just considering conventional monohull studies requires quite different sets of design and analysis processes and tools, dependent on each option's degree of innovation. Thus, any computer aided (preliminary) ship design (CAPSD) toolset ought at least to spell out the limitations on the degree of novelty each can address. Furthermore, I would argue CAPSD tools should be able to assist the designer in undertaking a concept design process that can fully explore as wide as possible a range of design options, if the concept phase is to be comprehensive and creative.

So why should the concept phase be comprehensive and creative? I recognise such an approach can pose a problem for a large number of routine commercial (transportation) ship designs, given that once a outline proposal has been offered to shipyards to bid there is traditionally just six weeks to respond with a contractually binding concept design, hence the distinction that my remarks apply primarily to "complex vessels". However in a perfect (or future?) world, if the intended owner is to be sufficiently confident that the solution space has been adequately explored and that the design will meet the right set of matching requirements, then a much more comprehensive concept design process ought to be being undertaken. Anything less is a compromise and the extent to which the initial owners of many transportation vessels dispose of quite new ships suggests this is questionable (if commercially common) design practice.

But having said concept design is really sophisticated – and that any simplification needs to be made with the conscious realisation it may produce 'the wrong option' through the lack of an adequate exploration of options and requirements – one should explain why the concept phase is different to the rest of the ship design process. It is important to realise this is not solely due to it just obviously being the first phase of design.

To whet the appetites of the readers of *The Naval Architect*, I precis below a significant section of the Special Edition paper addressing three significant issues that make the concept phase so different. Fundamentally the difference is because its aim is different. The rest of the ship design process is concerned with the preferred/chosen solution that emerges from the concept phase and which is then

progressively worked up so that a ship can be built. The aim of the concept phase itself is to find, or elucidate, what is actually required and both capable and affordable to be designed and built. Design in concept is vital to explore options and trade them off with the requirements. So concept tools must primarily aid this exploration rather than rush into ever more design detail just because we can.

1. Requirements Elucidation is the main task in Concept: This really needs to be better appreciated by the design community (especially if involved in complex vessels) and has, sadly, still to be generally accepted, even though I coined the term in 2003. There is clearly a relationship between effectiveness, cost and risk. The fact that cost, time and risk require to be assessed (along with effectiveness) through design solutions means requirements elucidation has to be a dialogue with the requirements owner, best

Type	Example
Second (stretched) batch	RN Batch 2 Type 22 frigate and Batch 3 Type 42 destroyer
Simple type ship	Most commercial (transportation) vessels and many naval auxiliary vessels
Evolutionary design	A family of designs, such as VT corvettes[1] or OCL container ships[2]
Simple (numerical) synthesis	UCL MSc student designs
Architectural synthesis	UCL research design studies (see Section 6.2 of Andrews, 2018)
Radical configuration	SWATH, Trimaran
Radical technology	US Navy (3,000t) Surface Effect Ship proposal of 1970s[3]
1 (Usher & Dorey, Trans RINA1982) 2 (Meek, Trans RINA 1970, 1972) 3 (Lavis et al, Marine Tech1990)	

Table 1: Types of Ship Design in terms of Design Novelty

driven by the ship concept designer. That is the essence of what Rittel and Webber (1973) identified as the "wicked problem", which is often misunderstood as saying complexity is wicked, which it may well be, but their point is rather that "sorting out what is really wanted" is the real challenge to be nailed on the head before going into classic (ship) design (i.e. post-Concept). Furthermore, this particularly applies in the maritime domain if there is no simple measure of cost/effectiveness, such as Required Freight Rate for transportation carriers.

2. Designing at Concept should be Inside-out: The need for the 'inside-out', or architecturally based, approach to ship synthesis is a consequence of now being able to synthesise new ship concepts holistically. Actually both inside and out aspects of the new design need to be pursued simultaneously – but in emphasising what is now possible through computer graphics I have striven to overturn more than a century's obsession with a ship's underwater form. I have therefore coined this as an architectural approach to ship synthesis, which at UCL we call a Design Building Block approach. This can then broaden consideration in ship synthesis to wider aspects, such as early consideration of Human Factors issues, which naval architects have been criticised for not giving sufficient early design emphasis.

3. The Key Design Choice is the Style of any design option: Making a style selection is the crucial design decision. This is necessary both to get any (overall) form, from the broadest of functional needs, but also in going down from the macro and major aspects (examples to be found in Table 1 of the Special Edition paper) to the many micro-decisions that that characterise detailed design. The key point about style is that it is the responsibility of the design engineer. So the ship designer has to recognise that engineering design involves making a choice, even if that is to repeat what was done before. The good designer does so having weighed up the alternatives as best they can.

So as with ship architecture, the question is does any highly automated CAPSD tool enable the necessary style issues to be investigated as part of Requirement Elucidation, that being the task in the concept phase? Ignoring such issues means that past practice (or whatever is buried in the software) is being unwittingly accepted by the concept designer, which is poor design practice and neither comprehensive nor creative.

En passant I would also query the continued use of the Ship Design Spiral as an adequate representation, especially when used to describe the complete ship design process, even with Roy's adaptation. Furthermore, I would caution the use of so-called optimisation techniques for early stage "holistic ship design" beyond providing the designer with limited decision-making guidance.

I should not want readers to think that I am a Luddite about the latest developments in CAPSD, rather I am sceptical that automation of a sophisticated designer-led process necessarily assists in meeting the aim of ESSD. The Special Edition paper discusses several new design related techniques being explored by several leading centres of research in complex ship design, some of which were presented at the recent International Marine Design Conference, at Aalto University, Helsinki (also covered in October's *TNA*). It shows that research into the complexity of early stage ship design is alive and well. It would be good to see greater discussion of ship design developments in, and adoption by, the profession of such innovative approaches.

Professor David Andrews, FREng, PhD, FRINA, RCNC
Professor of Engineering Design
University College London

Roy de Winter responds

I welcome Professor Andrews' response and comments to the article I wrote on Accelerated Concept Design. I agree with his statements that the Concept Design phase, no matter the type of ship, should be comprehensive and creative to come to a truly novel design that meets the requirements given by the client and those established by regulating authorities. Additionally, we feel his that comments 'in a perfect world' the complete solution space should be adequately explored to identify the desired solution are spot on.

At C-Job Naval Architects we work closely with our clients to ensure their vision, ideas and ambitions are translated into a practical ship design with the latest technical and sustainable design solutions. Our Research and Development department help push the solution space boundaries by, for example, exploring CO_2 neutral fuel types such as ammonia (NH3) and wind-assisted propulsion.

Requirement Elucidation, designing inside-out and styling a vessel are all important steps of Concept Design. Once an initial Concept Design is set up by a naval architect, we also want to deliver the most optimal design variation. That is why we then parameterise certain aspects of the designed vessel to optimise it for total cost of ownership, stability, safety, draft and/or any other objective that is important for the client. As optimising a Concept Design using the design spiral can be labour intensive, time-consuming, and repetitive we came up with what I described in my original article as the holistic Accelerated Concept Design optimisation framework. This framework makes sure that:

1. Not only safe but also radical design changes can be made in a small amount of time
2. Complex engineering questions that come up from unique design variations can be answered with confidence, and
3. Every possible combination of decision parameters are considered with the use of surrogate assisted optimisation algorithms.

The optimal design solutions following this optimisation process can then be studied and learned from. This way, we combine the required creativity and automated optimisation technique to optimally exploit the decision freedom that is typically still present in early stages of ship design process. As words can only go so far in explaining our (thought) process, I would like to extend an invitation to Professor Andrews to come visit C-Job Naval Architects in Hoofddorp, The Netherlands so we can share ideas and discuss this topic in person. *NA*

Roy de Winter,
Research & Development Engineer
C-Job Naval Architects

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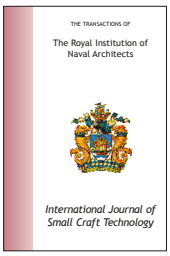

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