THE NAVAL ARCHITECT

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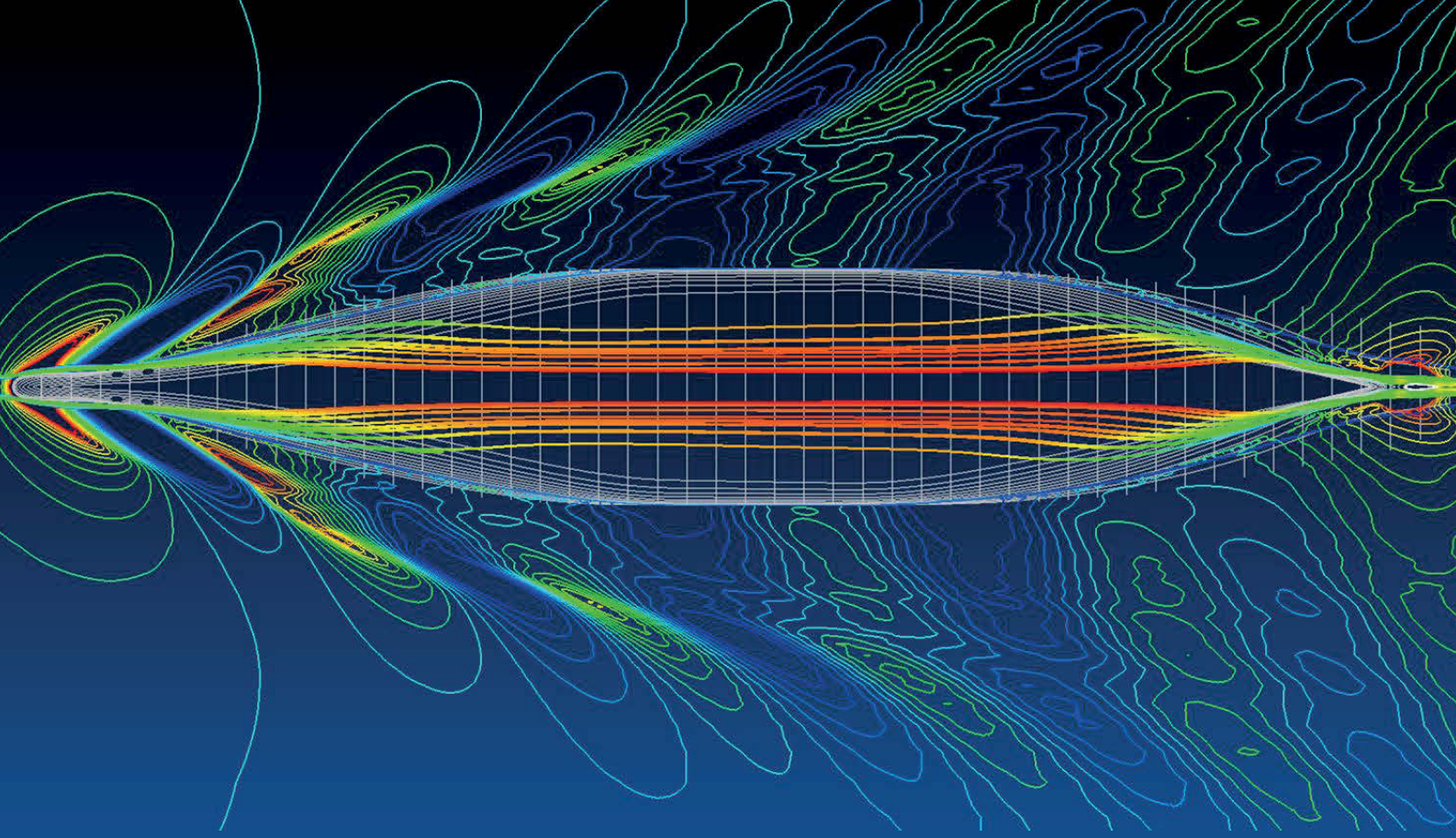

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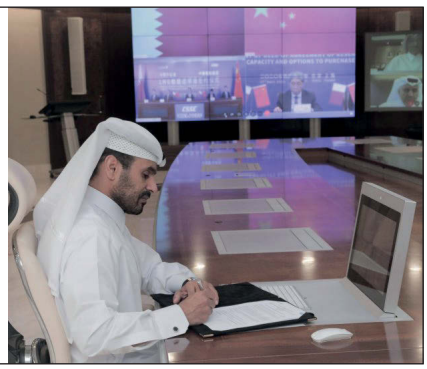

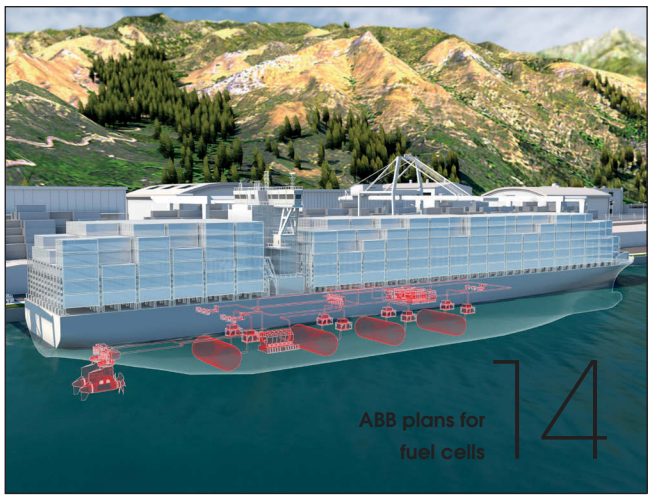

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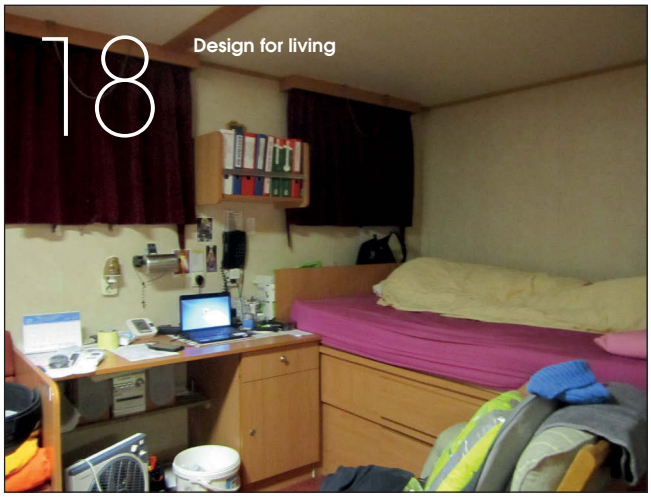

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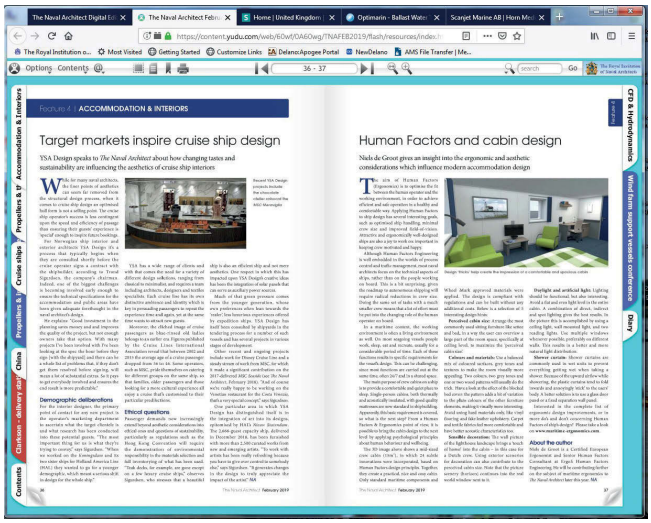

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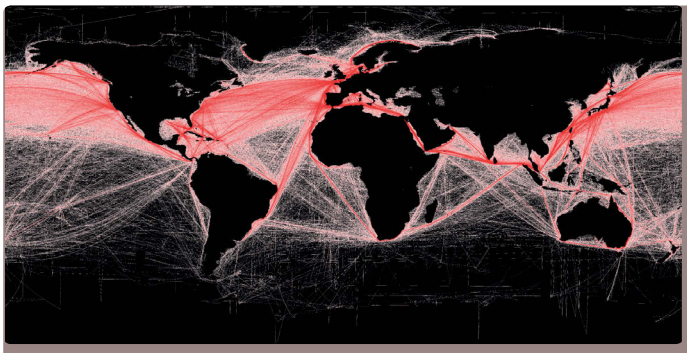


How do we get out of this?

Global trade and shipbuilding must prepare to take a hit.
Source: B.S. Halpern (T. Hengl; D. Groll)

At the time of writing the UK is still in coronavirus lockdown, with an expectation that this situation will probably continue for at least a couple of weeks longer, followed by a gradual easing of restrictions. For many of us it's been a strange hiatus from our regular lives, a time for introspection and a realisation that things will never be quite the same when we come out of it.

Moreover, that 'breathing space' before facing up to the realities of a global recession appears, for now, to be tempering the worst of the panic. The maritime industry's response, at least as can be gauged from the articles I've read or webinars I've listened in on, seems to be phlegmatic and even cautiously optimistic. While global trade can never be truly put on hold this may be the best opportunity to hit 'reset' and take some decisive steps towards addressing the challenges of Maritime 4.0 and climate change.

One view I've been particularly keen to hear is that of shipping economist and sometime *TNA* contributor Martin Stopford, who has just published a whitepaper: 'Coronavirus, Climate Change & Smart Shipping: Three Maritime Scenarios'. It's in part an evolution of ideas Stopford outlined for us in an article in last year's *Future Ship 2050* supplement (published with March 2019's *TNA*) but also factoring in the dramatic developments of the last few months and where it may lead the industry.

Stopford begins by pointing out that even before the pandemic disruption world fleet growth was widely expected to slow down, from 4% last year to a projected 2% this year due to reduced shipyard deliveries and increased scrapping. But much hinges on whether the worst is behind us. In the best scenario, the rest of the world follows China's example and some kind of normality is restored over the next few months, allowing for seatrade growth to begin picking up again by 2022, continuing at 3.2% p.a. up to 2050.

However, should Covid-19 prove to be a recurrent problem over a longer time period, with sporadic outbreaks and potentially social unrest in some countries, then we could be facing a recession that continues into the middle of the decade. In the most extreme scenario, Stopford projects seatrade could fall by 15% by 2024, with growth from 2025-2050 stuck around 0.7% p.a. This would have profound consequences for shipbuilding and climate change targets.

When considering the corresponding implications for shipbuilding a sharp downturn in orders appears inevitable, even in the best scenarios. Stopford notes the distinction between 'ships required' to meet supply demands and those which may be ordered on the whims of owners or even governmental policies, but believes vessel speed will be the main variable. In a perfect world, shipowners would like to be able to carry on operating their vessels at design speeds (14knots) and demand for new vessels would peak in the early 2030s at around 25 million dwt. It also depends heavily on zero-carbon solutions (and infrastructure) becoming readily available in time to meet IMO's targets.

What is more probable is that either slow (12knots) or even eco speeding (10knots) may be necessary to achieve those targets. Such speeds could spur a need for more tonnage but Stopford suggests that much will depend upon counter cyclical investment over the coming years and this speculative ordering will be compromised by the recession.

In addition, he anticipates a phased approach to decarbonisation, with three 'waves of development'. The current generation of ships with optimised onboard systems, giving way to gas and hybrid vessels in the early 2020s, with the third phase being zero-carbon propulsion systems beginning in mid 20's.

Where things become interesting is when you add all the 'high growth' scenarios together. The 'best case' of 3.2% trade growth and vessels operating at a 14knot average design speed leads to annual carbon emissions of 771 million tonnes (Mt) p.a. by 2050, well in excess of IMO's 450 Mt target. By contrast, vessels operating at 12knot slow speed (2.2% growth) would emit 324 Mt, and vessels eco speeding (0.7%) just 184 Mt.

All three scenarios assume the uptake of the three waves of technology, it's just that the influence of these improvements is far outweighed by slower operating speeds and reduced trade growth. In other words, the pursuit of decarbonised solutions will count for little if it's not supported by other efficiency measures and perhaps more focus on sustainable growth.

It would be extreme to call globalisation a folly, but the case is becoming increasingly persuasive that the future lies in regionalised production, manufacturing and distribution. In such a world short-sea shipping – also ideal for exploring new technologies – could become the backbone of the merchant fleet, rather than the megasized behemoths of today.

After all, couldn't one argue that globalisation is at the heart of our current predicament? *NA*

Covid-19

IMO's advises during Covid-19 pandemic

The International Maritime Organization's (IMO) 31st council session took place by correspondence due to the Covid-19 pandemic; the first meeting not held live in its history.

While acknowledging the continuing work of crew, seafarers and shore-based workers during the pandemic, as well as the industry's ability to deliver vital goods and medical equipment worldwide, the organisation has advised a series of actions to keep the shipping industry flowing.

IMO has urged flag and port states to ensure maritime traffic and shipping services for world commerce to remain available and in smooth operation, as well as to preserve seafarers' welfare, including but not limited to wages, shore leave, sick leave, medical assistance access, food supplies and repatriation.

The organisation also backed a pragmatic approach to repairs, survey and certification and licensing of seafarers, and it encouraged governments to exchange best practises for keeping maritime transport workers safe during Covid-19.

Kitack Lim, IMO Secretary-General, comments: "The situation needs practical and pragmatic approach, in these unusual times, to issues like crew changeovers, resupply, repairs, survey and certification and licensing of seafarers."

Looking towards its 32nd session, the IMO has asked its member states to submit proposals which will safeguard shipping services from unnecessary disruption due to the Covid-19 pandemic.

LNG

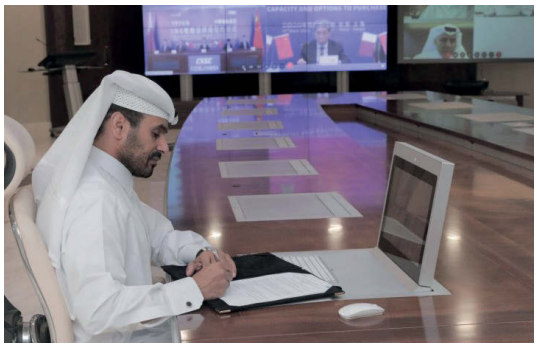
CSSC and QP sign LNG carrier deal

Qatar Petroleum (QP) and China State Shipbuilding Corporation (CSSC) have remotely signed a RMB20 billion (US$2.86 billion) agreement that reserves a significant portion of CSSC Hudong-Zhonghua Shipbuilding's LNG construction capacity until 2027.

Signed by Lei Fanpei, chairman of CSSC and Saad Sherida AI-Kaabi, president and CEO of QP and the Minister of State for Energy Affairs in Qatar, it's the Chinese shipbuilding sector's biggest export contract to date and will provide for QP's future LNG carrier fleet requirements.

This includes the largest carrier fleet program in the LNG industry's history, QP's ongoing North Field expansion projects, which will increase Qatar's LNG capacity from 77 to 126 million tonnes per year.

The vessels will be built according to CSSC's latest 174,000m³ LNG carrier design, which has been customised by the Chinese company for Qatar.



Saad Sherida AI-Kaabi, president and CEO of Qatar Petroleum, signs LNG carrier agreement

"The carrier has the world's leading performance for efficiency, reliability and environmental conservation, demonstrating CSSC Group's great efforts and commitment to the success of Qatar Petroleum's projects. The agreement signed today will be an important milestone for the cooperation of CSSC Group and Qatar Petroleum," says Fanpei.

Decarbonisation

LR and UMAS assess zero carbon fuels

Lloyd's Register (LR) and the University Maritime Advisory Services (UMAS) have published a report assessing shipping's current and future fuels, identifying optimum solutions for GHG emission reduction targets.

The joint report, which is supported by the Methanol institute, builds upon previous research into Zero-Emission Vessels (ZEVs) and decarbonisation pathways made by the two companies. It examines the adoption of zero-carbon fuels compared to fossil-based fuels through community, technology and readiness perspectives.

Katharine Palmer, global sustainability manager at Lloyd's Register, explains: "Our work with the Methanol Institute and UMAS is designed to help industry stakeholders to understand the dynamics and interactions between technology, investment and community readiness within the wider range of ship types, sizes and operational profiles."

The study demonstrates that, from a technology perspective, ZEVs are conceivably possible in the next few years, irrespective of which zero-carbon fuels are deemed most economically favourable.

Screening and assessment undertaken in the report is on a fuel-agnostic basis for various zero-carbon solutions and covers onboard procedures for bunkering, onboard storage, processing, conversion and population. It aims to provide an insight into the barriers disrupting market

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uptake and help the industry identify opportunities for new approaches.

The report also examines energy source price scenarios, ship-specific case studies, total cost of operation, fuel related voyage coasts, impact on cargo carrying and sensitivity analysis to evaluate investment readiness.

Digitalisation

DIMECC issues maritime transport guidance

Finland-based Digital, Internet, Materials & Engineering Co-Creation (DIMECC) has released a new Sea for Value (S4V) programme that provides research-based guidance on regulation, business, data usage and sharing, and standardisation for maritime transportation, through which the company aims for wide societal influence.

S4V is a co-creative venture that brings together industry, research and governmental organisations. Developing and experimenting with future fairway services, including remote pilotage, is the focus of S4V's first project, 'Fairway', which is funded by Business Finland and its industrial partners.

Moreover, the S4V is linked to One Sea, the autonomous maritime ecosystem of global commercial organisations committed to achieving maritime autonomy (see also p.34), which DIMECC coordinates. A series of 'roadmaps' have been created as part of the One Sea that include a timeline towards 2025 covering operational, technical, security, traffic control and ethical themes.

DIMECC states that future S4V projects will concentrate on maritime digitalisation to support One Sea's aim of a safer, more efficient and sustainable maritime transport and logistics chain, and will be modelled using DIMECC's earlier ventures such as LIFEX, which focused on AR, VR and vibration damping.

Jukka Merenluoto, senior ecosystem lead at One Sea, explains: "The DIMECC S4V programme is closely linked to the One Sea roadmap in creating safer, more efficient and sustainable maritime transport through the exploitation of digital opportunities. Implementing the programme will bring us closer to realising the One Sea vision, which is to deliver an autonomous maritime ecosystem by 2025."

Covid-19

Cruise ship sector goes virtual

In light of the Covid-19 pandemic, Celebrity Cruises has taken virtual delivery of *Celebrity Apex*, the second ship in the company's Edge series.

The delivery took place through video conference with officials from Chantiers de l'Atlantique shipyard, where the cruise ship was constructed. As with traditional deliveries, the ship's captain, Dimitris Kafetzis, ordered the exchange of French and US flags while each countries' national anthems played.

Lisa Lutoff-Perlo, president and CEO at Celebrity Cruises says she anticipates *Celebrity Apex* to begin sailing out of Barcelona on 20 May and adds: "Every delivery is unique just as every ship is unique. While the circumstances are quite unique right now, it's fitting that such an innovative ship as *Celebrity Apex* would have a digital age delivery."

Furthermore, Princess Cruises has cancelled the naming ceremony of *Enchanted Princess*, due on the 30 June. The vessel's delivery has also been delayed after the temporary closure of the Fincantieri shipyard in Italy.

Covid-19

Survitec resumes work in China

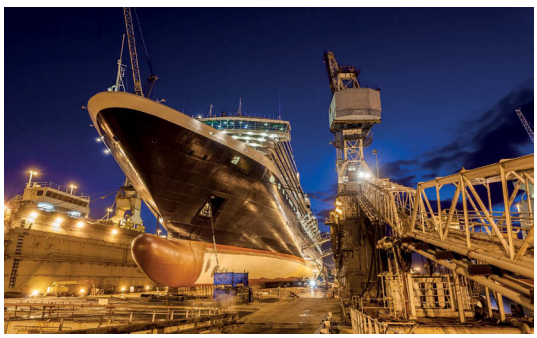
Following the country's three-month lockdown, Survitec has scaled up its operations in China, while maintaining extra security measures.

Utilising a suite of safety precautions, which includes provision of personal protective equipment such as face masks and hand sanitisers, the company aims to prevent infection and ensure the safety of both its workforce and customers.

"While strict controls remain in place, we are pleased to see signs of recovery in China. Many of the country's shipbuilding and repair years have reopened and most ports are now operational. However, out foremost concern is keeping our teams, customers, and suppliers safe at all times," explains Jena Tan, regional vice president, APAC, Survitec Marine.

Survitec says it has made efforts to minimise operational impacts on its customers by maintaining its service and manufacturing facilities to complete and delivery orders safely and adds that this continuity planning is essential. *NA*

Bottlenecks and equipment delays ahead if operators leave their drydocking and servicing requirements to the last minute



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Total	148

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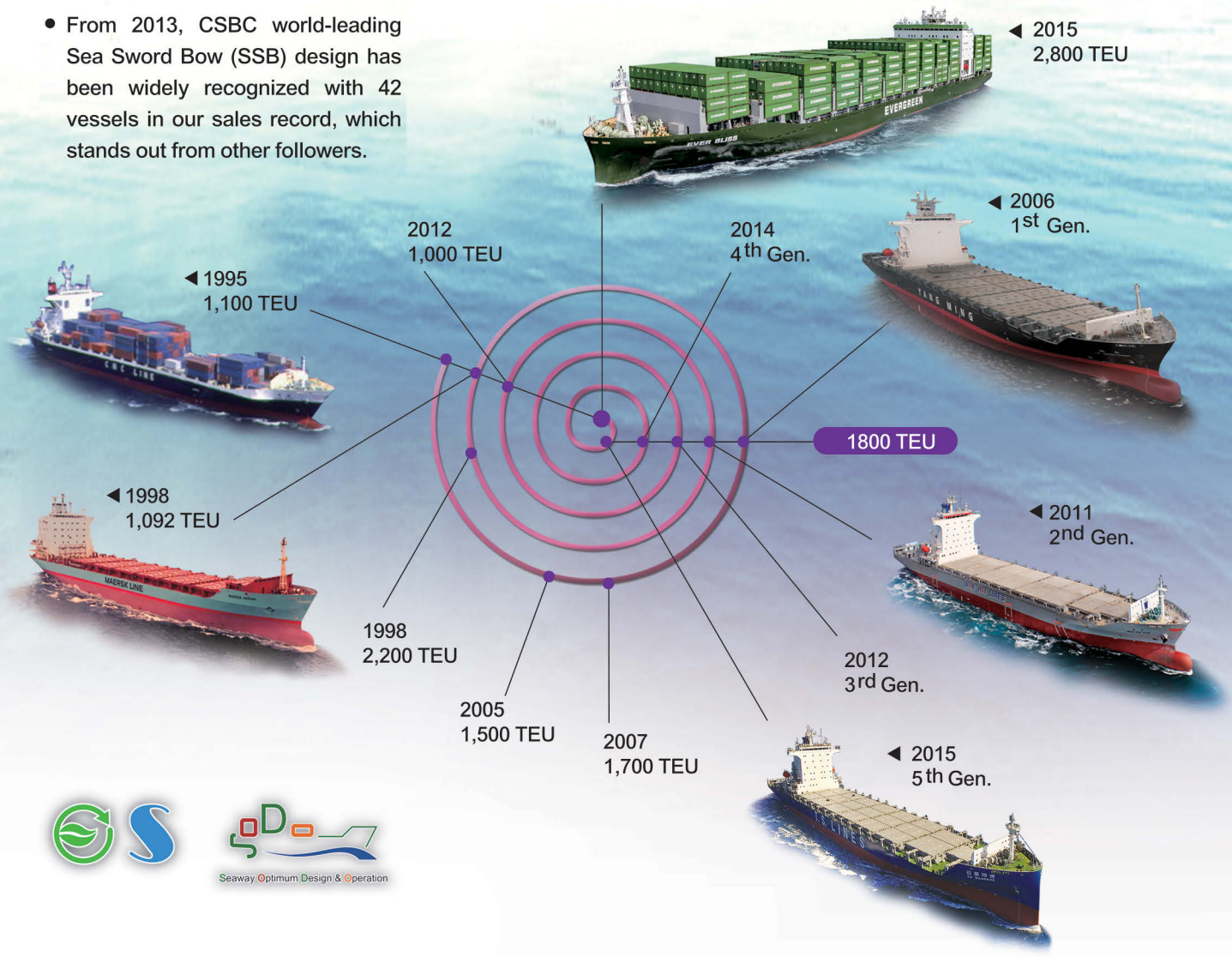

Seaway Optimum Design & Operation

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Shipping in disarray as oil goes negative

Malcolm Latarche looks at the ongoing impact of the coronavirus pandemic

Almost the world over there has been just one topic dominating news, conversation and political discussion throughout April and that is Covid-19.

With populations in most countries around the globe under lockdowns, industrial and commercial activity has been severely disrupted and that has had consequences for all sectors of shipping – some good but mostly bad.

The cruise sector has suffered most with all vessels stopped and several having passengers affected by the virus. The last cruise ship to operate was the *MSC Maginifica* which left Italy in January for a 117-day world cruise. But after calling at Wellington on 10 March, the captain having recognised the danger to passengers – none of whom were ill or had come into contact with the illness – refused to let any go ashore at the next port. Thereafter the ship made one or two more calls for supplies but as ports began to prohibit and restrict vessels, there was nowhere left to go so the ship began a six-week voyage back to Italy avoiding any ports and arriving on 20 April.

Container operators are also having a hard time cancelling sailings and seeing cargo volumes drop by around 11% in the first quarter of 2020. The continued lockdown has not helped as many retail outlets in Europe and the US are closed and demand for consumer goods, clothing and other items mostly produced in Asia has dropped dramatically.

That will not be good news for shipowners with newbuildings under construction and it was perhaps a less than auspicious time for the title of world's largest container ship to be passed to a new holder. Last July, *MSC Gulsun* took the title and this April relinquished it to Hyundai Merchant Marine's *HMM Algeciras*. *MSC Gulsun* was built by Samsung and *HMM Algeciras* by DSME.

The title of largest container vessel is determined by TEU capacity. MSC's vessel had a nominal capacity of 35,756TEU and the new champion claims 23, 964TEU. However, the size difference is hardly discernible with both vessels being 399.9m in length and the MSC vessel having a slightly wider beam (61.55m as opposed to 61m) but a maximum draught 2.5cm less than its rival. In practice neither vessel is ever likely to be loaded to its full capacity.

If the first four months of 2020 have been dismal for cruise and container ships, the very opposite has happened for tankers, but not for the reasons that were expected. Last year, anticipating more demand for crude to produce the low sulphur fuels dictated by the IMO's 2020 sulphur cap, tanker operators were quite bullish about demand.

As it has transpired, demand for oil has collapsed. The combination of over production caused by a breakdown in the pact between OPEC and Russia has coincided with demand falling off a cliff. That could have been a disaster for tankers, but the supply demand imbalance has meant that all onshore storage capacity is fully utilised, and tankers are in demand purely for their storage space.

Crude carriers – even vintage ships – have suddenly acquired a value such that the largest ships can command daily rates which in one case on 27 April hit US$300,000 per day for a Trafigura VLCC. It is not just crude carriers that are finding employment as floating storage. Demand for products particularly jet fuel, petrol and diesel has also nosedived and at the end of April around 250 product tankers were being used globally for floating storage. Just as for crude carriers, hire rates are increasing and sentiment is that they could well continue to do so for some months yet.

The most bizarre outcome of the current circumstances around oil is that in the second half of April, the futures price of West Texas Intermediate crude actually dropped below zero – at one point hitting the astonishing record low level of minus US$40.48 per bbl. This was a peculiar aspect of futures whereby buyers had agreed to prices earlier in the month and were suddenly faced with the prospect of not only having to pay for the oil but also for indefinite storage as well. The following day when the next month's future price was set there was an instant rebound to US$21 but with no change in the situation, that too has slid to stand at being only just in double figures.

Low oil prices of course mean low bunker prices and the drop in the differential between VLSFO and HFO has shrunk to a little over US$30 at Rotterdam. With prices at those levels, the economic case for scrubbers is difficult to make causing some owners to consider cancelling planned installations. If the competitive case for scrubbers is difficult to make, so too shippers are saying is the 2020 fuel surcharges introduced by most liner operators in anticipation of vastly increased bunker prices. *NA*

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Electrical accessories

Bolidt's bold new lighting

Developed in-house at Bolidt's R&D centre, Bolideck LED lighting is the company's latest edition to its range of ship deck solutions for the cruise ship and superyacht industries.

Available in a range of formats, shapes and colour palettes, the company says it offers its customers a high degree of design flexibility; the lighting can be integrated within larger deck spaces, as well as in functional features such as exits. Bolideck LED's programming can produce different patterns, with varying intensities across individual LEDs and can appear invisible when switched off.

Jacco van Overbeek, director of maritime division at Bolidt, comments: "With any number of lighting patterns possible, Bolideck LED brings additional freedom of expression for cruise ship interior designers. But it could also be used as a means to enhance safety."

Its first installation was onboard TUI Cruises' *Mein Schiff 2*, a 2,894 passenger capacity cruise ship, and the company has since seen further follow up orders from multiple undisclosed owners.

The LED lighting was installed in one bar, multiple passenger access areas, and features as part of the ships 'floor diamonds' artwork, which Bolidt developed alongside its partners ICArt and design studio SOFTlab.

Working cooperatively with Meyer Turku and SPT Finland, Bolidt's artwork floor installation took place while the vessel was under construction at the Finnish shipyard. Aside from Bolidt's Bolideck LED, *Mein Schiff 2* features 10,000m^2 of the brand's other products onboard, including the Bolideck Future Task, Select Soft and Select Hard.

Fuel cells

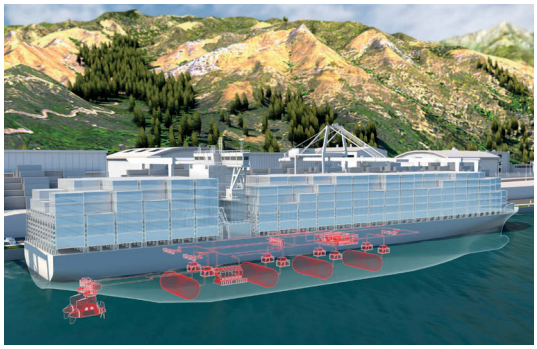
ABB signs megawatt fuel cell production deal

ABB has signed a Memorandum of Understanding (MOU) with Hydrogène de France (HDF), which envisages the two companies jointly assembling and producing a megawatt-scale fuel cell system to power ocean-going vessels.

ABB and HDF plan to optimise their manufacturing capabilities by building on a pre-existing partnership with proton exchange membrane (PEM) fuel cell solution provider, Ballard Power Systems.

The new fuel cell system will be produced at HDF's facility in Bordeaux, France, but will be based on ABB and Ballard Power Systems' megawatt-scale fuel cell power plant, which the two companies developed in a previous collaboration.

ABB claims that the entire energy chain will be clean, as it will use renewables to produce its hydrogen, and its fuel cells will convert chemical energy from hydrogen to electricity through an electrochemical reaction.



ABB's concept illustration for the large, fuel cell-powered vessel

Juha Koskela, managing director at ABB Marine & Ports, says: "With the ever-increasing demand for solutions that enable sustainable, responsible shipping, we are confident that fuel cells will play an important role in helping the marine industry meet CO_2 reduction targets."

Ballast water treatment systems

BIO-UV receives IMO and USCG approval

IMO and the Unites States Coast Guard (USCG) have given type approval to BIO-UV Group's next generation low-flow rate ballast water treatment system (BWTS).

The BIO-SEA L easy-to-fit system features a newly designed UV-reactor suitable for the luxury yacht, expedition cruise and offshore vessel sectors, which have ballast water pump flow rate capacities below 100m^3/h.

BIO-SEA L uses a fully compliant, 6kW UV lamp arrangement, which in its USCG mode treats flow rates of 20-90m^3/h, and up to 120m^3/h in IMO mode. The company states that while some UV-based BWTS's for low-flow rate vessels repurpose the same high-power consuming, high wattage lamps as used on larger capacity vessels, its BIO-SEA L technology is separate to its pre-existing BIO-SEA B product.

The new system features different UV lamp and casing materials, in which up to three 6kW lamps can be added to the BWTS skid, each one incrementally increasing flow rate capability by 30m^3.

Bio-UV adds that its new BWTS technology has both low capex and opex. Xavier Bayle, technical and R&D manager explains: "Each unit features reactors with a 6kW lamp, which is less expensive to replace than the larger lamps. This means reduced maintenance for the crew, fewer spare parts have to be kept onboard and as the automated UV sensors adapt to the water quality, energy consumption is better regulated, reducing energy consumption and preserving lamp life."

The company also claims that its BWTS skid is the market's most compact system; a two-part modular product which will simplify onboard delivery, installation and integration, and can be delivered in eight weeks.

Propulsion

Schottel to propel heavy lift crane vessel

German propulsion manufacturer Schottel will provide Jan De Nul's 236.8m heavy lift crane vessel, *Les Alizés*, with its full propulsion package.

Les Alizés, which will be built by CMHI Haimen shipyard in China and is due to begin operating in 2022, is capable of lifting 5,000tonnes. Its propulsion system will include four electrically driven SRP 610 FP rudder propellers. Installed at the stern, each one has a 3.30m propeller diameter and 3,000kw input power, allowing the vessel a maximum speed of 13knots.

The propulsion package includes two SRP 610 R retractable rudder propellers, with a 3,000kW input power and 3.00m propeller diameter, as well as two STT 7 FP transverse thrusters, with 2,600kW input power and 2.79m propeller diameter. The system's retractable fittings feature an eight degree downwards-tilted propeller shaft, which will minimise thruster-thruster and thruster-hull interactions.

Les Alizés' thrusters will also feature Schottel's DNV-GL type approved, patented Leacon sealing system, which controls seal leakage, prevents water from entering the gearbox and oil from escaping into the sea. It is also considered a non-oil-to-water interface, does not need to use environmentally acceptable lubricants and complies with the US Environmental Protection Agency's VGP regulations.

Schottel claims that the system ensures precise position keeping during dynamic positioning (DP) operations and that the vessel has optimal propulsion efficiency and maximum manoeuvrability.

Additionally, the vessel will be equipped with Schottel's condition monitoring system, featuring 24/7 onboard surveillance of its propulsion units. Data collected helps to avoid unnecessary part exchanges and downtimes as the thruster maintenance can be based on its current condition and will prolong *Les Alizés* dry-docking period from 5–7.5 years.

***Les Alizés* will be equipped with a full Schottel propulsion package**

LNG

LNG's GHG emissions can be cut, says Wärtsilä

Wärtsilä claims LNG is the fastest, simplest pathway for shipping to achieve IMO's 2050 goal of halving shipping's greenhouse gas (GHG) emissions.

While software company Thinkstep states that LNG engines emit less GHG than HFO, a report by the International Council for Clean Transport (ICCT) claims gas engines are worse emitters than conventional diesel. However, Wärtsilä notes that ICCT's report calculates a 5.5g/kWh methane slip based on a low-pressure, duel-fuel medium-speed gas engine and does not reflect the latest advancements in gas engine technology.

Wärtsilä adds that a value of 2.8g/kWh could be observed from its existing 46DF engine, which more closely reflects current technology in four stroke engines and would incur a 14% emission reduction over a 100-year timeframe, according to Thinkstep report calculations.

The company also states it has reduced 75% of the methane slips in its dual-fuel engines' in the last 25 years and anticipates further advances in the next three years. Wärtsilä adds that its gas engines will soon have an advantage over traditional diesel due to advancements in emission abatement in the fuel production and supply chain.

Moreover, Wärtsilä is confident it can further reduce methane slip and GHG emission from low-pressure, duel-fuel engines. The company has manufactured around 2GW of land-based engines that operate on 1g/kWh methane slip that it plans to have operational by 2023, which would cut GHG on a tank-to-wake basis by 23% over 100 years and 14% over 20 years.

Wärtsilä is also investigating a series of technical advancements to reduce methane slip, including optimising the engine combustion chamber, reducing valve overlap duration and timing gas admission, and adding a portion of hydrogen to the combustion process. Although the company admits that adding hydrogen could adversely increase NOx formation and potentially overstep IMO Tier II and III regulations.

It also proposes that the uptake of smart marine technology will minimise emissions, and the trend of hybrid systems that use energy storage alongside engines can run consistently at optimum performance with a low GHG output. *NA*

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Remote inspection at large during the pandemic period

Amid the difficulties caused by Covid-19 and with engineers unable to reach vessels, CCS completed inspections by means of remote survey and issuing electronic certificates

Throughout China's Covid-19 prevention and control period, in accordance with its 24/7 service tenet and the deployment requirements of local governments and leading control agencies, CCS began new service means for remote inspection of ships.

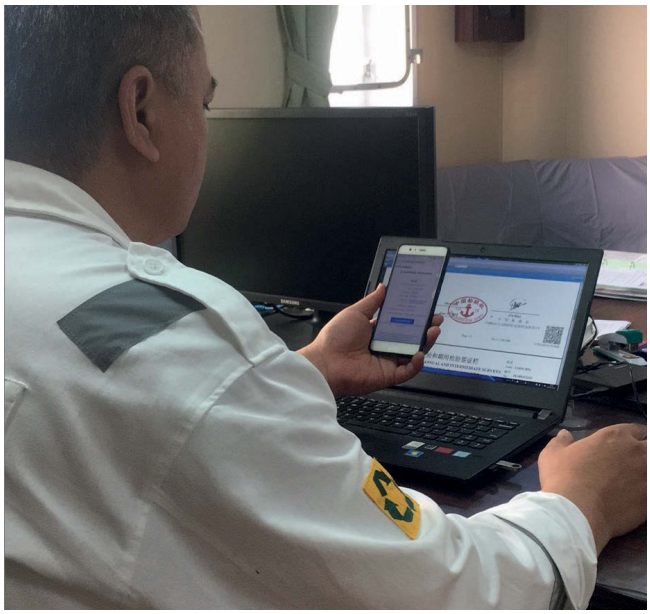
On 2 February, a Chinese vessel applied to the Jiangyin Office of the China Classification Society (CCS) for damage inspection, due to the loss of its left anchor. CCS established a remote connection with the vessel's crew to obtain detailed damage and repair information. A remote inspection, in accordance with CCS's 'Guidelines for Ship Remote Surveys', was carried out and this long-distance operation ensured that the ship sailed on time.

At the end of 2019, CCS issued and officially implemented its 'Guidelines for Ship Remote Surveys'. The introduction of this new inspection technique copes with situations when CCS surveyors urgently need to complete boarding inspections but are unable to board vessels due to limiting conditions.

"This is a new step in the deep integration of CCS global inspection service and online information technology, and the development of CCS in a new inspection mode to meet the timeliness of customer service.

The remote inspection of the vessel breaks down restrictions related to the environment, location, human resources and other aspects of the boarding inspection, and can provide services for any urgent inspection needs and technical support in a timely manner to meet the requirements of CCS's global customers," a spokesperson from CCS commented.

Particularly during the Covid-19 prevention and control period, CCS played an important role in remote service and actively fulfilled its commitment promise that 'all inspection applications shall be accepted'. Combined with its research, development and effective promotion of ship electronic certificates, the classification society carried out remote inspection work on a global scale. In doing so, they not only met the pandemic prevention and control requirements, but also solved the practical problems of shipowners.



China Classification Society (CCS) continues to complete remote surveys and electronic certifications

As of the end of February, CCS have accepted 83 remote inspections, which have been successfully implemented for the ships of Maersk Group, Greek shipping group Marmaras and COSCO Bulk Shipping, as well as other well-known shipping companies in China and abroad. In part, this has guaranteed the safety of ships and contributed to overcoming Covid-19 prevention and control related restrictions.

Innovative test method

In recent years, the CCS inspection fleet has continued to grow. By the end of 2019, the scale of CCS's inspection fleet has reached 34,974 ships, with a total tonnage of 155.12 million tonnes, an increase of 7.2% over the end of 2018. Among them, there are 4,193 international ships of 112.04 million gross tonnes with an average age of 9.5 years, 28,135 domestic ships totalling 41.29 million gross tonnes with an average age of 12.2 years and 2,646 ocean fishing boats, 1.79 million gross tonnes, with an average age of 7.2 years.

Due to CCS's large global fleet, an increasing amount of accidents occur, and the society has to deal with the resultant inspection needs globally, which places a higher demand on manpower and time costs.

However, if the surveyors are supported by ship to shore communication and information technology to reach the ship, then they can carry out a survey to the same standard as the on-site inspection, without boarding. In this way, surveyors can establish video connection to obtain the relevant inspection process information (video connection, inspection photos, videos and documents) and provide services remotely for ships across the world.

Surveyors can complete remote inspections using CCS's 2019 'Guidelines for Ship Remote Surveys'

With the help of the developed communication technology and professional technical judgement, the 'isolated' surveyor can draw an inspection conclusion. This not only helps shipowners to solve sudden problems of ship safety and pollution prevention but also, compared with an onboard inspection, can reduce the ship's time spent interrupted and awaiting inspection. This can effectively reduce the company's operating cost and improve the ship's navigation efficiency.

Some ship types (such as polar navigation offshore support ships, or salvage vessels) will also be the direct beneficiaries of remote inspection due to their operating characteristics and as most sail in specific waters far away from the shore.

Remote Survey Guidelines

As part of its 'safety, environmental protection, creating value for clients and society' mission statement, CCS organised for the 'application research on ship remote surveys' project to be carried out. It included in-depth research into the needs of a shipping company, discussed and analysed the applicable inspection and carried out a pilot inspection.

These research results were refined into the 'Guidelines for Ship Remote Surveys', which further clarified the implementation of remote survey, its application process, application scope and inspection requirements. According to the specifications of this guideline, CCS service outlets can evaluate and implement remote inspection for an applicable vessel, and the shipowner can also directly and clearly master the specific requirements and steps for the remote survey.

After this guidance was issued, the CCS Zhejiang branch carried out a remote inspection on the damage and repair of the left windlass of Shanghai Dingheng Shipping company's oil/chemical tanker *Dingheng 5*, which became the first application of the Guidelines for Ship Remote Surveys.

The left windlass broke down while the vessel was unloading at a wharf. As there are many restrictions on the dismantling and inspection of the ship's equipment and the entry and exit of personnel at the wharf, it is not easy to repair and inspect the faulty equipment. Additionally, the boarding procedures are very complicated; it takes time and boarding is not guaranteed.

Therefore, the customer proposed remote inspection requirements to CCS. The society's Zhejiang branch assessed and confirmed that the ship has the conditions for remote inspection and with the support of CCS headquarters, it communicated with the customer and decided to go ahead with a remote damage and repair inspection.

The surveyors used video link to understand the full extent of the damage, guide the ship to move from the wharf to the port anchorage for further inspection and repair, and follow up the repair process of the windlass. Through the efforts of all parties, the damaged equipment was permanently repaired, the remote inspection was successfully completed, and the ship sailed on time.

Solving shipowners' problems

Pan Zhongbing, director of operation and classification division of CCS headquarters, said: "As a ship classification inspection and audit service organisation, CCS plays a very important and unique role. Our work is to serve customers, ensure the safety of life at sea, and prevent air and marine pollution caused by ships."

At present, CCS has eight overseas branch service outlets around the world, and each branch's business scope covers several countries around its location. In the face of the Covid-19, CCS headquarters plans to organise overseas branches to collect information about the control restrictions and inspection accessibility of ships that have recently docked in China from ports of various countries. The society aims to summarise and release this information in time to keep customers up to date with current procedure, ensuring that all inspection and certification work is carried out in an orderly manner.

Pan Zhongbing stressed that, when confronted with pandemic prevention and control, ship remote inspection plays a particularly important role. Using advanced IT to realise remote communication and inspection with the crew, the surveyor can minimise the number of trips, avoid unnecessary contact with ship and shore personnel and reduce the risk of infection. At the same time, combined with the ship electronic certificate service launched by CCS at the beginning of 2018, after remote inspection ships can receive the certificates and documents issued or signed directly through the CCS network, so as to ensure the normal and orderly operation of ship inspection service.

These become important service means for CCS to stick to the 'pandemic' level of inspection; isolate the virus, but not isolate the responsibility, reduce the spread of the virus, but not the inspection and service standard.

The operation and classification division of CCS headquarters shared the society's remote inspection experience with authorities of flag states and has encouraged authorities to accept it's conduct of remote inspection in the applicable statutory cases. CSS has received some positive responses from authorities, which means that CCS remote inspection will have a broader application in the subsequent battle with pandemic prevention and control. *NA*

Accommodation beyond the MLC

Researchers at Cardiff University's Seafarers International Research Centre are preparing to publish a set of recommendations to shipowners and builders for the improvement of seafarers' accommodation

The Seafarers International Research Centre (SIRC) at Cardiff University is nearing the end of a research project, begun in 2018, investigating the onboard living and working conditions for seafarers.

The SIRC's findings are built on two questionnaire-based studies the SIRC conducted by researchers with seafarers in China, the Philippines and the UK. Surveying around 1,500 individuals in each study, the first survey was carried out in 2011 and the second in 2016, before and after the Maritime Labour Convention 2006 (MLC) came into effect, respectively. These were followed up with face-to-face consultations with accommodation engineers and naval architects at shipyards in Japan, China and Korea, as well as visits to manufacturers and suppliers and to merchant ships. The researchers found that in many areas of provision for seafarers, clear improvements had been made since the MLC came into force, for instance in the field of health and safety.

However, one area they found to have seen relatively little improvement was in the quality of the accommodation and amenities provided for seafarers while on board. Based on their findings, the SIRC researchers have now drawn up a set of recommendations for use by shipowners in outfitting newbuilds in a way that builds on the standards set out in the MLC to improve seafarers' conditions.

Speaking about the original motivation for carrying out the research, Iris Acejo, an SIRC research associate says: "The impact of the design of vessel accommodation on seafarers' mental wellbeing and levels of fatigue has received limited attention in the last 50 years. Cabin furnishings have barely altered in the 25 years that researchers have been undertaking shipboard studies at the SIRC and there is evidence that recreational facilities are being minimised on modern ships as a result of the prioritisation of cargo carrying capacity."

Inefficiently designed or insufficient storage space can contribute to cabins becoming cluttered and uncomfortable

Designing for habitability

Presenting at The Royal Institution of Naval Architects' Human Factors conference in late February this year, Acejo detailed the researchers' recommendations. These include options for incorporating the human element into the outfitting of cabins and amenities for workers onboard at the design stage, focusing accommodation design on genuine habitability and thereby improving seafarers' quality of life and ability to carry out their duties. The recommendations can be grouped into the following areas:

- Improvements to cabin design to maximise storage space;
- Reductions in noise and vibration in cabins;
- Incorporation of more controls (ie, light and temperature) within cabins;
- Increased access to natural light on board;
- Improvements to leisure facilities.

Many of the ideas brought forward by the SIRC research are suggested in the MLC itself, albeit largely in the form of non-mandatory guidelines outlined in the Part B sections of the Convention, intended to be given 'due consideration' by shipowners and operators, rather than in the more strictly regulated Part A. In general, the researchers' recommendations – intended as supplementary to the MLC minimum standards - offer more specific ideas about what may actually be useful in seafarer accommodation, suggesting, for instance, that cabins contain "a minimum of four coat hooks", as opposed to the MLC's "sufficient coat hooks".

Likewise, where the MLC does outline some specific requirements regarding volume of storage space, the SIRC recommendations goes further in its detail of the arrangement of the storage, saying, for example: "double wardrobes/cupboards should be installed in all cabins with a clothes rail in one half of the cupboard and a minimum of five removable shelves in the other half of the cupboard."

While many of the recommendations are in this relatively modest vein, focusing on encouraging shipowners to be more efficient with the use of furnishings and available accommodation and storage space, there are also suggestions for altering the construction of the cabins themselves to improve seafarer comfort. Regarding minimising the transmission of structural noise into cabins, the researchers say that noise reduction cabin systems should be fitted as standard to all cabins, incorporating insulated double walls, insulated window boxes designed

to prevent the transfer of structural noise, floating floors incorporating a noise damping material beneath the steel surface.

There are also suggestions for improving the recreational facilities available to seafarers, including recommendations for the inclusion of an indoor swimming pool, basketball court or full-size squash court and a purpose-built gymnasium on all vessels engaged in international trade. Furthermore, inclusion of a lounge large enough to accommodate all seafarers employed on board, satellite television in all seafarers' lounges, and unrestricted internet access in all cabins at speeds which permit face-to-face video calls.

If some of the recommendations sound like they may be too ambitious in terms of cost and space for shipowners and operators to consider them, there are also more obvious practical implications for the smooth and efficient operation of vessels which could be precipitated by an improvement in seafarer accommodation. For instance, it is expected that reduced vibration and noise in cabins will lead to improvements in sleep quality. "Fatigue has been identified as an immediate or contributory case in 1 in 10 accidents at sea," Acejo adds, which points to what could be a more persuasive angle for the shipowners and operators at whom the recommendations are aimed. Acejo continues: "The range of retention issues reported by seafarers includes quality of working conditions… With better shipboard conditions, there will also be fewer adverse consequences for seafarers' health, as there will be less disruption in their circadian rhythms. For similar reasons, the likelihood of accidents and onboard injuries will also go down."

Next steps

Originally planned to be published in the first quarter of the year, the SIRC has decided, in light of the ongoing Covid-19 pandemic, to postpone the release of the recommendations until such time as owners, operators and builders are in a better position to hold face-to-face meetings and give the work due consideration. That said, the researchers' ultimate intentions for their set of recommendations, once made available, are unchanged. Acejo says: "The next step for us now is to get this out there and use every means possible to convince shipowners to buy into this to some degree, and also take this to shipyards to motivate them to consider the possibility that there's a market out there for this kind of ship. We intend to release these recommendations as a document to back up shipowners when they're ordering ships."

On the subject of where the responsibility for bringing about the changes to cabin design lies, Acejo suggests that any improvements in seafarers' living conditions can only be implemented through stakeholders' combined efforts, explaining: "Shipowners have to be aware of which changes are possible when they are ordering new builds. Shipbuilders on the other hand should have the capacity to carry out such changes."

"The findings will be disseminated to regulators, class societies, shipowners and to stakeholders such as the International Transport Federation and the Nautical Institute. Naval architects and shipbuilders will also be contacted in an effort to achieve a paradigm shift in relation to what is seen as the minimum acceptable standard for accommodation or good practice in the area." ***NA***

The SIRC's research can be viewed online at: www.sirc.cf.ac.uk

Covid-19 and cruise ship conversion

Matthew Jensen, director of Fraiserline Architecture, considers the practicalities of transforming a passenger vessel into hospital ship, should the need arise

During my lifetime, I have never witnessed such a crisis as Covid-19. We watched the agonising hours of the twin-towers attack in Manhattan, the devastating Tsunami of Indonesia, and then the colossal *Costa Concordia* disaster – none of which have compared to the silent killer of the coronavirus. In the UK, we've seen substantial pressures on the NHS both in terms of resource and personnel, but also on capacity. Aside from politics, frustration lingers as many vacant hospitals still sit within our country, most like giant time capsules. One might hope or assume these vast NHS former sites could have served during these times, but sadly, most are now in substantial decay.

Covid-19 and strategy

The travel sector has been significantly impacted by the pandemic and the aviation industry has temporarily converted a large number of wide-bodied passenger airframes in order to accommodate medical cargo. Within the US, the consequences of Covid-19 have impacted heavily upon vast, well-established medical institutions. Temporary shelters were installed for the deceased, and even more alarmingly, for some patients who urgently required treatment.

In the light of this crisis, Carnival Corporation came forward and offered its fleets as floating hospitals that might "help relieve stress on the health-care system". President Trump even echoed a notion of support for the idea, and the general response back from politicians was positive.

With much industry concern now looming around the cruise community, the question arises: how easy is it to temporarily convert a luxury cruise liner into a working hospital? I crudely

reference back to the Battle of Britain, when some of the finest of ocean liners of the day were converted into troopships and operated at considerable over-capacity during a desperate time of need. Some of these liners were also converted as hospital ships to support the front-line.

Conversions

Modern cruise liners today are equipped with comprehensive medical facilities for the need of general passenger welfare and have the capability to perform procedures similar to those at a small land hospital. Most vessels include a morgue facility as certain itineraries contain a number of days at sea, and this requirement for the deceased is paramount to brand protocol and marine regulatory requirements.

However, the only ship I have experienced with a vast medical agenda is arguably the grandest warship ever constructed; the aircraft carrier HMS *Queen Elizabeth* built by BAE Systems. I proudly collaborated on the Royal Wardroom and Admirals Dining Quarters that served as a space for leisure during peacetime, yet had the unique capability to convert into a medical refuge during troop repatriation.

This vast project gave me the understanding of adaptability with utilitarian spaces on ships, especially when meeting the needs of a military design brief. This has proven that passenger liners could integrate medical 'hard-wiring' across most public zones of the ship, whether the objective be for general care or more intensive procedures. Moreover, we recognise that a passenger vessel can provide much needed refuge for countries which face medical capacity shortages, and the ability for ships to manoeuvre with limited disruption only has benefits.

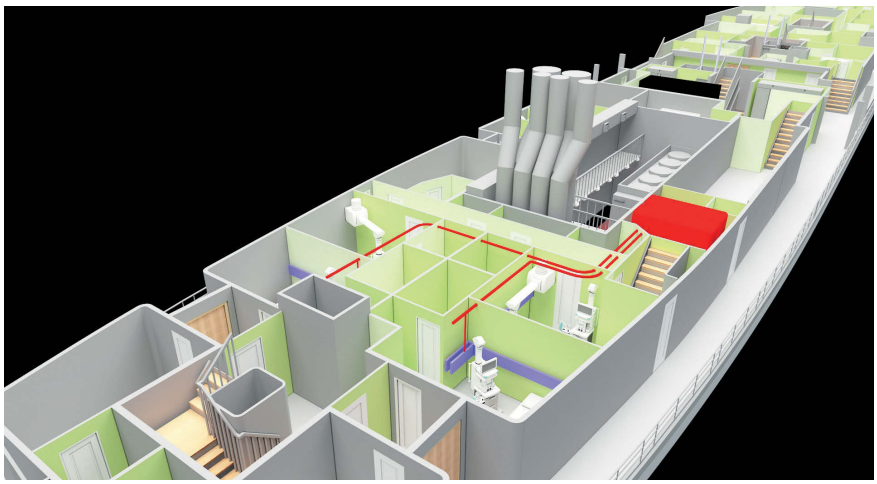
Design and architecture

Fortunately, we belong to a generation where innovation is a fundamental aspect of ship design. Generally, most vessels today contain a 'hook-and-ride' type of outfitting, meaning the ceilings, ducts and interior fixtures can easily be accessed for maintenance and regulatory inspection (SOLAS, FPP, IMO). Mindful of the possibility of a potential medical conversion, futureproofing for medical oxygen, power, networks, IT, communication, HEPA, and sterile water could be tethered to the existing infrastructure in order for rapid activation and flexibility should the need arise. All that remains is the strategic planning for the locations of wards and private treatment areas, and it is regarded that 'outside cabins' and 'suites' provide adequate spatial flow for medical equipment, transitional movement and fast mobility if used as private care spaces.

This then raises consideration of the design approach for future interior environments, and whether they should demonstrate merit for medical robustness, containment and sterile cleanliness. A regulatory review of design specifications could be assessed against performance with adaptability for crisis conversion a further consideration in addition to standard marine compliance. It poses a series of questions for the cruise industry.

Perhaps regulatory bodies will now endorse the features of crisis conversion as part of Marine Industry 4.0? Similarly, a small percentile of fleets, but not all, could be 'crisis conversion ready' and able to demonstrate all of the back-end requirements should it be instated. This could be indicated by a small regulatory marking on the ship, and recognition as a 'crisis conversion ready' vessel would make it a respected and valued asset to one's nation.

One final question remains: could we now see cruise ships being considered resource to support countries during a time of global crisis such as Covid-19? *NA*



The 'hook-and-ride' outfitting of modern ships makes a cruise-to-hospital conversion relatively straightforward

Cabins can be easily converted into private treatment areas

Policing the seas: drone-based emission monitoring

EU member states can expand their emission monitoring beyond their ports with EMSA's drone technology

While shipowners are feeling the pressure to adhere to IMO's global sulphur cap, governing bodies are left with the challenge of how to enforce the new legislation. Leendert Bal, head of department safety, security and surveillance at the European Maritime Safety Agency (EMSA), recently spoke with press about EMSA's Remote Piloted Aircraft Systems (RPAS).

More commonly referred to as drones, RPAS can be used for a range of governmental tasks, including emissions monitoring, which support the enforcement of the EU Sulphur Directive 2016/802. Bal explains: "It's a way to do enforcement at sea, not only having to wait until vessels come in to port, it can measure, at sea, what kind of fuel a ship is burning."

CO_2 and SOx combined sniffers installed on EMSA's RPAS can monitor emissions at sea

As of February 2020, EMSA have six large drones and nine smaller models under contract, weighing between 23-235kg and with an endurance range of 6-12 hours. All of the society's RPAS are equipped with Automatic Identification System (AIS) sensors, which give a complete picture of the vessel's movements, as well as distress sensors in the event of an emergency.

For the purpose of emission monitoring, lightweight drones are fitted with SOx and CO_2 sensors, known as sniffers, which can measure the emission content present in a vessel's plume. EMSA's RPAS are already in active service; they operated in Denmark both in 2017 and between April and June last year and in 2020 the agency has plans to carry out operations in The Netherlands, Greece and France.

The sniffers currently installed on EMSA's RPAS are solely for measuring carbon and sulphur emissions, however Bal notes that the technology's potential extends beyond this. "There are all varieties of sniffer technology. We already have CO_2 and SOx combined sniffers onboard. If instead we want to measure black carbon emissions or other small particles in the future, then the technology is already there."

During an emission monitoring operation, the dual mini sniffer on the RPAS measures the target vessel, Bal explains: "Once the wind direction and plume location is determined, the drone will approach the vessel, enter the plume, and collect CO_2 and SOx measurements to calculate the fuel sulphur content. Quite often, this process is repeated twice for an average calculation, to get a precise reading.

This information, including the measurement, among other data including the vessel's IMO number and photograph, will be added to a central database available to all member states, so that when this vessel comes into port the authorities can follow up on the results."

Although Bal notes that the dual mini sniffer can reach an accuracy of +/- 0.03 for 0.10% sulphur fuel, he adds that the measurement is not yet for prosecution purposes. "It's more of an indicator as to whether the ship is compliant or not with the sulphur regulations. Authorities will have the vessel's measurements during the RPAS flight, and they can check the fuel onboard."

For each measurement, EMSA generates an emission report. It includes a quality score between 0-10, which can also be affected by wind directions and the RPAS's position within the plume. Though Bal says this measurement acts as another indicator of how reliable the reading will be, he insists that the accuracy of the agency's RPAS is not the reason why its readings aren't yet used in prosecutions. "We are dependent upon national authorities and what they want to accept as evidence. As RPAS is new technology, it needs to reach a certain level of acceptance before it will be used for a specific vessel."

Drone market

Bal notes that the drone industry in Europe is still fairly immature and the

EU's experience with it is very limited, with few well-developed companies and a small market. Despite this, the level of interest is high and EMSA has received requests from 15 member states, which specify the RPAS's rental period and purpose. "Actually, there is a big demand from member states for these types of emission monitoring service, they really see this new challenge for them to enforce the sulphur rules."

Once a member state has acquired the RPAS, they are given command and control. However, Bal adds that the drone deployment is complex as there is no general, overriding legislation in place relevant to drones in airspace and the agency has to treat each loan independently.

"It's one of the biggest hurdles we have. We enter into a dialogue to identify which specific area the RPAS will fly in and exchange this information with the nation's authorities to get a permit to fly in that location." He also notes that the issue is compounded as some interested countries have very stringent aviation authorities and it can be difficult to receive the necessary permits to carry out the operation.

EMSA's minimum deployment for its RPAS is three months and the agency hopes to extend this to allow users to experience the technology's full capabilities. "The data can seem like alien information; it needs to be integrated into how the member state collect and work with the information on a national level in their overall surveillance chain," adds Bal.

However, Bal admits that along with a small market, the cost is also high, as this expense falls mainly on EMSA. Bal explains: "It's fully financed by the agency; the member states only have to take care of local costs that enable the drone to operate in that particular location."

The society's RPAS deployment is limited by its funds, which is unlikely to increase overall. Instead Bal anticipates a change in the agency's annual budget, which is approximately US$87 million (€80 million). "My expectation is that in the next two or three years there will be an expansion of this type of service and most likely we will see a shift in our budget, a larger proportion will be fed from surveillance to emission monitoring. As of course, drones are expensive and so we cannot solve all requests, its budget permitting."

EMSA's RPAS fly into the vessel's plume to measure its fuel sulphur content

Pollution monitoring

Additionally, EMSA's RPAS are utilised for pollution monitoring and response tasks, as its technology can use radar, optical and infra-red sensors to detect vessels and objects at sea. The agency intends to set up a system of oil pollution response (OPR) vessels globally to assist the member states with any significant pollution accidents that may occur over time. Four OPR vessels have already been equipped with EMSA's RPAS technology, and a further four installations are planned for 2020.

In March 2019, the sinking of the Grand America saw the deployment of two RPAS-equipped vessels, mobilised by French authorities to assist in the cleaning up of the vessel's oil spill. Bal explains: "These were two of our first ships equipped with quadcopters and pre-installed equipment that onboard professional pilots operate on behalf of the on-sea commander." Bal adds that the drones were used to get further insight into the pollution, the extent of which is not entirely visible from the bridge.

Bal comments that available uses for EMSA's RPAS are broad and the agency could be considered a market leader in the field. "We really are a front runner. I think it's the first time that such large-scale drone operations have been brought to the civil domain, and certainly in maritime. I'm unaware of any equivalent scale of service in the world even."

Satellite imagery

As part of its maritime safety and security directive, EMSA also utilises satellite images to monitor global traffic primarily across Europe, as well as for EU-flagged vessels voyaging across the world. "We receive about 25 million ship positions per day in our data centre, from around 80,000 vessels, which we can translate into Traffic Density Maps (TDM) – a new product we've developed as of 2019."

Though primarily used for vessel monitoring, Bal adds that TDM's have also been used by governments and companies for the installation of new wind farms at sea. "Of course, to achieve this you must take into account where there are vessel movements. With the Traffic Density Maps, you can observe how sea space is utilised."

However, in 2020 the agency is considering ways to create Emission Density Maps (EDM), which Bal says could involve a combination of recorded data and the use of satellites. He adds that the EDMs could potentially calculate the 'local burden' of each country from emissions in shipping. EMSA intends for the EDMs to be in service by late 2020 and to make them available for the member states and the public at large. *NA*

The role of low carbon fuels and innovative technologies within the EEDI

A landmark study will examine the potential to integrate low carbon fuel solutions and innovative technologies into the index, writes Georgios Plevrakis, director of global sustainability, ABS

The IMO Energy Efficiency Design Index (EEDI) is the only regulatory measure to date that aims to directly reduce ship emissions by promoting technical design improvements and the use of more energy efficient and less polluting marine equipment and engines.

As a measure of carbon intensity, the EEDI formula takes into account power consumption and generation, speed and deadweight and assigns a distinct value to each individual vessel that represents CO_2 emissions produced in order to transport one tonne for one nautical mile.

Currently in 'Phase Two' of its deployment, the EEDI's requirements are now expected to significantly strengthen when phase three enters into force. However, before this milestone is reached, the future of the EEDI, especially in relation to low carbon fuels, is set to be studied.

ABS together with partners Vessel Performance Solutions (VPS) and Arcsilea have been awarded the project to prepare a technical study on behalf of the European Union that looks into existing challenges that need to be resolved in the near future while the IMO considers the possible introduction of EEDI's fourth phase.

The study will analyse the EEDI's ability to deliver improved designs and evaluate its relationship to various new fuel efficiency technologies. It will also consider updated targets for improving vessel efficiency, speeding up the deployment of low carbon solutions and make recommendations on how to integrate innovative technologies.

The first of its four tasks will provide a comprehensive review of the EEDI implementation to date, the extent to which it has incentivised and motivated new designs and technologies, the effect on reference speeds and installed power levels in the context of the upcoming third phase.

Georgios Plevrakis

This includes the limitations to improving efficiency via installed power reduction (while maintaining a constant chosen fuel scenario), focusing on ship types to which minimum propulsion power requirements apply (tankers, bulkers, combination carriers).

It will also study the EEDI formula and whether it sufficiently captures and reflects the benefits of different design and technology applications, the influence of 'correction factors' for different ship types and potential issues with the verification process.

New fuels and technologies

The second major task will be to assess how new technologies and fuels can play a part in improving the energy efficiency of ships and their carbon intensity in a design state. This will include an overview of existing technologies and alternative fuels including LNG, bi-derived and alcohol fuels that could improve the energy efficiency of ships.

This task will evaluate the take-up of alternative fuels and technologies so far and examine the robustness of the verification guidelines issued by IMO. It will examine implementation to date onboard of ships towards meeting the requirements of EEDI Phase One and Two assessing at the same time their effects on EEDI values, enabling a deep dive into how to implement them far more widely onboard ships.

The result should increase the industry's understanding of why specific design trends and changes are underway in certain segments and why certain design modifications and technology changes may not be occurring.

As the first and second tasks are undertaken it will be possible to judge with accuracy how innovative technologies and alternative fuels can be incorporated into the next phase of the EEDI. This will include an examination of the EEDI framework in terms of robust verification guidelines so that these fuels and technologies deliver what is expected of them.

This should enable the industry to understand how far highly innovative solutions – such as air lubrication or wind propulsion – can contribute to carbon reduction. These technologies have been much discussed but to date lack a common approach in terms of verification. It is vital to be able to properly assess the impact of such technologies before the EEDI proceeds to the next phase.

Accelerating decarbonisation

The study will then explore a roadmap beyond phase Three and towards Phase Four, to include proposals for how updated carbon reduction/energy efficiency targets could be set, taking into account the analysis already conducted. It should be noted that the study does not include the explicit setting or recommending of new targets.

Central to this process will be to examine how the industry can speed up the adoption of low carbon and non-conventional power

solutions such as electric batteries, fuel cells and hybrid solutions to reach IMO's goals.

This will include addressing challenges related to the specific carbon factor associated with each fuel, since not all of the alternative fuels proposed as solutions to shipping's carbon reduction challenge have a recognised carbon factor or reference in the EEDI regulation. This is an issue that has to be addressed if shipping wants to adopt more extreme alternative fuels such as ammonia and hydrogen that might enable the industry to arrive at the IMO's targeted carbon reductions by 2050.

The process will also examine ways of correctly integrating new technologies into the EEDI framework as they become available, estimating the impact in terms of environmental footprint based on the IMO targets.

The study includes a process of stakeholder consultation with industry actors, OEMs, consumers, public authorities and NGOs to feed into proposals related to the introduction and formulation of EEDI Phase Four.

The consultation will include identifying relevant contributors, developing the appropriate access strategy including questionnaires, interviews, expert panels, bilateral meetings, conferences and workshops to acquire a representative sample of the opinions of all stakeholders.

At least two workshops with administrations and other parties are foreseen with a view to building a consensus-based approach on the overall study recommendations, with the results subject to statistical analysis for validation.

A pathway for the future

A multitude of solutions have already been incorporated into the formula that sits behind the EEDI. The study will investigate how the industry might address new technologies and fuels from an EEDI perspective; understanding the new carbon factors and how the various technologies play out when properly evaluated.

Critical to this process is the verification of each technology or fuel's impact; whether the upcoming Phase Three of EEDI can incorporate the new elements of decarbonisation that are emerging. It's important to stress that the study does not envision changing the EEDI, rather it will examine how far it can be adjusted towards the requirements of the new age of decarbonisation.

During this process we will discover whether the EEDI is robust enough to take in and reflect these potential changes and still be a safe and useful tool. If not, how can we make it robust enough to meet the requirements of both industry and society? We don't know the answers to these questions yet, discovering them is the intention behind the study. *NA*

Transforming compliance with blockchain and DNA

Data sharing should be the linchpin of the drive towards greener shipping, argues Deanna MacDonald, co-founder of BunkerTrace and CEO of BLOC

With Covid-19 disrupting virtually all aspects of shipping, there has been plenty of speculation that it may put decarbonisation initiatives on the back burner for shipping. While undoubtedly there will be additional challenges to overcome, there is plenty of evidence to the contrary; that the first movers on decarbonisation will remain committed to a long-term strategy of sustainable investment and business practices.

Recent reports from McKinsey point to an important role for green tech in any recovery, arguing that, "not only does climate action remain critical over the next decade, but investments in climate-resilient infrastructure and the transition to a lower-carbon future can drive significant near-term job creation while increasing economic and environmental resiliency. And with near-zero interest rates for the foreseeable future, there is no better time than the present for such investments."

In shipping, a recent letter signed by some of container shipping's biggest customers, such as Lego, Nestle, Volvo and Ikea, argues that initiatives taken after the financial crisis of 2008 are not to be repeated to get the economy going again, but, rather, politicians should target a green transition for society.

The groundwork for green finance in shipping is already solid, with organisations such as the investors involved in the Poseidon Principles representing more than US$100 billion of loans in shipping, committed to disclosing the climate impact of their investments. These principles set a benchmark for what it means to be a responsible bank in the maritime sector and provide actionable guidance on how to achieve this, guiding investment towards the technologies and best practices that will help shipping to thrive in a zero-carbon economy.

Deanna MacDonald

So, how can we make a green recovery a reality? How can banks be sure that they are lending to green businesses who are genuinely committed to sustainability? How can we avoid unintended consequences or negative outcomes from a shift to different types of propulsion? And how can sustainable first movers ensure that they can benefit from their investments?

The challenge is that this requires radical forms of collaboration, with multiple stakeholders working together for a common goal, who may well have competing incentives. The data required for monitoring and assessing climate risk – data on fuel use, voyage details etc. – lives in many different places. Multiple class societies in different countries have some information, as do vessel operators, while banks have other datasets.

Currently, the only way to share and verify these datasets is through a centralised intermediary, as is the case in EU-MRV reporting, for example. This limits the kind of data that can be shared, and parties' willingness to share it, as well as adding extra layers of bureaucracy. Banks cannot feasibly go to 13 different class societies for data, and regardless, for owners and operators, sharing this is not often an option.

Blockchain is an integral role to play as a facilitator here. It has the potential to act as a neutral intermediary, by leveraging its nature as a permission-based, privacy-oriented means of storing data. In the same way as it allows trusted transactions to occur without the need for an overseeing intermediary, it can allow parties to exchange data they can trust, without the fear that it might be used by a competitor or put them at a disadvantage.

We can see how this might play out in the zero-carbon fuels supply chain, which is likely to be integral to any decarbonisation process. Going forward, for first movers, it will be more important than ever for products to prove a chain of custody. With biofuel, for instance, it is necessary to prove the feedstock of the fuel, and ensure it is not competing with other land use. Users may also need to demonstrate what percentage of biofuel was used for drop-in options.

Documenting this chain requires physical logging of data, as well as digital data transfer via blockchain. Currently, BunkerTrace facilitates this by combining synthetic DNA with blockchain. This solution tags and traces marine fuel, offering end-to-end oversight and control of the marine fuel supply chain aiming to help shift the industry towards more sustainable fuels. In its current form, it is used for documenting evidence of compliance with IMO 2020, but the same technology is being translated and applied to a zero-carbon fuel supply chain.

In this way, blockchain helps us to envision the mechanisms and platforms that connect green finance to the most sustainable operators, and a means for a green recovery from the current crisis. *NA*

A case for stringent scrubber wash water monitoring

Emma Johnson, maritime sales manager at Chelsea Technologies, discusses the benefits of rigorous monitoring technology for ensuring regulatory compliance

It is becoming increasingly difficult for shipowners to feel confident that the investments they are making across their fleets are sufficiently futureproof. This is especially true while economic disruption, potential impending environmental legislation and an expansion of technological options are currently muddying the waters.

The International Maritime Organization (IMO) recently implemented the 0.5% global sulphur cap, hailing an influx of alternative options for compliance introduced to the market, such as alternative LSFO and scrubber systems. The key factor in determining the 'right' compliance option is its value over the medium term, as it must withstand future environmental legislation and safeguard a sizable investment.

From shipyards to class societies and naval architects, there are a number of stakeholders feeding into the design and retrofitting phase of a vessel, which has the potential to add further confusion as to the 'right' compliance option. With all variables considered, how do you ensure and prove that you are recommending an option to a shipowner which is fundamentally future proof?

Let us turn to the case of scrubbers. A popular option for shipowners, scrubbers or exhaust gas cleaning systems (EGCS), remove particulate matter and harmful components from the exhaust gasses before discharging from a vessel. However, many shipowners are understandably concerned by the current debate and uncertainty around the environmental impact of scrubber wash water, and the potential for new regulation.

As of yet, the IMO is still to align all signatory states along one unified policy approach, however it is acknowledged that a lack of clear guidance on the measurement and methodology for

Emma Johnson

polycyclic aromatic hydrocarbons (PAHs) found in scrubber wash water is a pivotal issue. As a key measurement parameter, it is essential that shipowners are able to accurately detect PAH contaminants in wash water to prevent the discharge of harmful particles including unburned fuel oil into the sea, and in turn, futureproofing their systems.

Understandably, without any current agreed standards on PAH levels, shipowners are left uncertain as to whether to invest in scrubbers that they feel could risk becoming non-compliant with upcoming regulation. To curb this concern and assist shipowners in choosing the most suitable solution for their vessels, scrubber systems should be selected on their ability to deliver an accurate and consistent monitoring of scrubber wash water through an integrated system. A scrubber wash water monitoring system that conducts a rigorous and accurate analysis of wash water, measuring PAH levels, not only prevents harmful discharge into our oceans but also safeguards shipowners.

Therefore, owners looking for monitoring systems should ensure that what they install is able to perform the most stringent regulatory analysis, as required by the IMO, including PAH, pH, turbidity (to ISO 7027: 1999) and temperature. This will ensure robust and accurate measurements are made in accordance with regulatory requirements.

Installed on vessels across the global fleet, Chelsea Technologies' Sea Sentry provides users with a full-range PAH measurement using a proven and highly accurate sensing technique and has gained type approval by DNV-GL and Class NK. The science behind these parameters is robust and they represent the full spectrum of measurements accepted as being adequate for ascertaining the efficacy off all types of EGC systems on the market.

Sea Sentry is also highly adaptable, reliable and easy to manage at sea. The system contains self-maintaining features including an integrated air purge antifouling system, automatic monitoring of optical sensor window, automatic PAH measurement adjustments for turbidity, UV absorbance and temperature, and an integrated pump, de-bubbler, pressure relief system and flow metering.

In addition, Chelsea Technologies works closely with leading global scrubber manufacturers to provide shipowners a package solution designed to safeguard their confidence in the system. This includes ongoing research and development and an in-depth knowledge of the stringent standards imposed by regulators.

Investments can be precarious in the current climate. Therefore, all steps must be taken to validate any recommendations given to shipowners for compliance solutions, to enable peace of mind and safeguard operations.

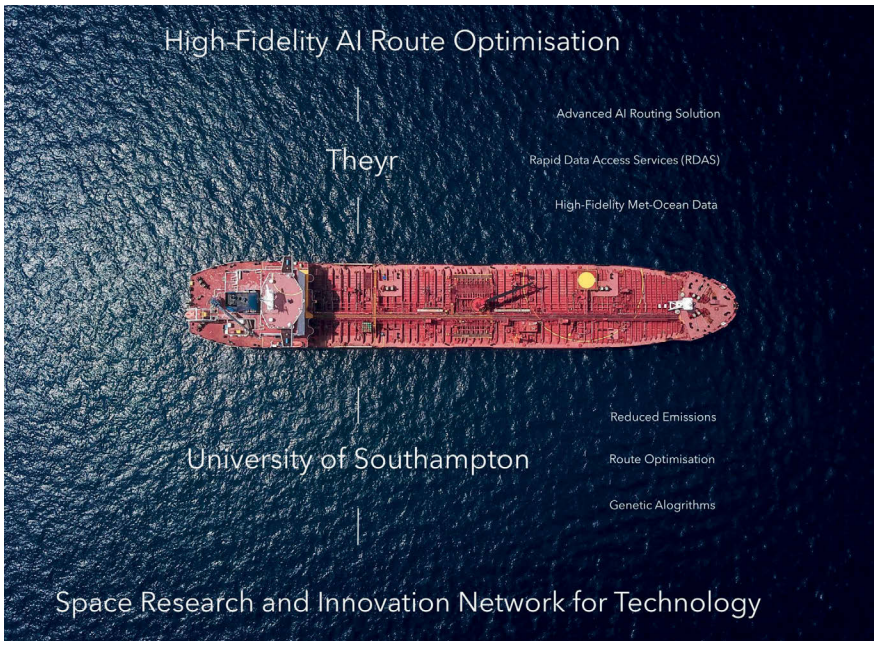
In the case of scrubbers, it is imperative that shipowners have an in-built capability to allow them to monitor and manage wash water, providing assurance, but also – vitally – a tangible resource for regulators, as well as insurers, charterers and financiers. To stay afloat in 21st century shipping means always being one step ahead of the curve. *NA*

SPrint to accelerate AI-enabled weather routing services

Met-ocean data provider Theyr and the University of Southampton have joined forces to develop a vessel routing application that will use the latest advances in algorithms

Launched in 2018, SPrint [SPace Research and Innovation Network for Technology] is a British government-backed scheme that brings together the UK's best academic expertise in space technologies with SMEs. Although part of its remit involves getting things into space, it's more focused upon taking advantage of satellite imagery and data that is being constantly generated by initiatives such as the European Union's Copernicus programme, much of which is freely available.

There are already numerous businesses involved with insurance, tourism, agriculture, transport, urban planning, and pollution monitoring that utilise this data, as well as companies specialising in low-cost access to space without the costly investment or the need for your own satellite. The idea of SPrint is to provide funding so that part of the innovation process is outsourced to a university.



The project will be funded by a grant from the £4.8 million SPrint programme

In March, met-ocean forecast data specialists Theyr Ltd and the University of Southampton (UoS) announced a project that would be funded by a grant from the GBP£4.8 million SPrint programme and will create an 'industry leading' marine vessel routing application. The project, which will run for one year, aims to bring together the latest in ocean forecasting data with leading edge 'Genetic Algorithms' developed by the UoS team to create a route optimisation module and thereby minimise GHG emissions.

There are a widening array of routing and voyage optimisation solutions available, but Theyr's particular niche is developing mechanisms which deliver meteorological and ocean data via third party applications.

"Our approach to the developing market requirements considers our routing module to be complimentary to Voyage Optimisation Software (VOS) E-Navigation and Maritime Internet of Things providers," says David Young, Theyr's managing director. "This module incorporates an operational met-ocean service and forms an essential element to an increasingly diverse and modular marketplace that provides a myriad of solutions."

Young believes that the nascent aspect of the current routing market opens up significant commercial opportunities for innovative and progressive companies such as Theyr. However, its ability to compete with larger companies will be significantly expedited by the SPrint project, given that both parties bring considerable commercial and technical experience to the project.

"The SPrint project enables the acceleration in development of a benchmarked routing solution. Working with UoS as a leading centre for maritime technology will provide a springboard for our commercial product and acceptance within this market. UoS brings 10 years of relevant R&D to the project and we couldn't ask for a better accelerator. Without SPrint its release would take some additional years to complete."

Genetic Algorithms

The project aims to exploit how two recently developed Genetic Algorithms methodologies can be used to take advantage of the increasingly higher fidelity data that is being made available.

"Genetic Algorithms are population-based search algorithms based on Darwin's theory of evolution. They were first introduced by Alan Turing, with a number of improvements having been proposed over the past decades," explains Adam Sobey, associate professor in the maritime engineering group at UoS, who is also co-lead of the maritime group in the data-centric engineering programme at The Alan Turing Institute.

"It is one of the key algorithms in the AI toolbox as it can accurately approximate

large-scale problems, maintaining the balance between exploration of the possible solutions and convergence towards the best solution in its search. These tools have been utilised in a range of applications including the design of spacecraft antennas for NASA and in computer games."

UoS researchers have developed new methods that build on these approaches by creating mechanisms that replicate multi-level selection, the theory of natural selection that proposes that the fitness of an individual can be judged not only on their own fitness but also the collective of individuals with which they are associated (e.g. a wolf and the pack it belongs to). This has led to an algorithm that exhibits a high diversity and is particularly strong on large or constrained problems.

Meanwhile, another approach, currently under development with Quaid-i-Azam University in Islamabad, looks at the crossover mechanisms in the algorithm, changing the probability that determines how similar children in a new generation are to the parents. This method has been shown to increase performance on dynamic problems over the multi-objective evolutionary algorithm based on decomposition (MOEA/D), the strongest convergence-based Genetic Algorithm.

The research of UoS and Theyr aims to develop a path-routing algorithm, or set of algorithms, that can be used on different problems, from short paths with higher fidelity met-ocean data, to longer paths with lower fidelity data. "This will future-proof our software against these increases in fidelity and provide leading performance over competitor software, reducing the emissions at sea through more effective utilisation of high-fidelity data," says Young.

To help them achieve this, the project partners will also have access to the UK's largest academic supercomputer, Iridis 5, which is located at the UoS campus. With more than 20,000 processor-cores providing 1,305TFlops at peak output and 2.2PB of storage, it will be used to speed up the verification process.

"It allows us to simultaneously run a considerable number of simulations, and therefore we can provide a more accurate verification as we can run a larger number of scenarios to ensure the algorithm has top performance across a number of different conditions," says Sobey.

"The idea for the verification case is to run some realistic routes from real ship data. We will be looking at a specific route and the met-ocean conditions at that same time period to see whether our predicted routes can improve on the performance that the vessel took in those conditions. We will replicate this process a number of times to see when the VOS provides the best performance and the types of conditions where the GHG savings can be highest."

Indeed, Young asserts that ultimately the 'bottom line' for the project is empowering shipowners to cut their emissions. "The potential savings for adopters of VOS technology go beyond the balance sheets of board rooms; they offer significant reductions in GHGs.

"It is an imperative that the shipping world finds a cleaner path. This technology is an incremental and imperative step towards a more sustainable future." *NA*

Towards autonomous ships – Flag State involvement and regulatory aspects

Chris Balls considers the implications that autonomous ships may have for SOLAS, MARPOL and other maritime regulatory instruments and legislation

Shipping is a highly regulated Industry with a vessel's Flag State having responsibility for ensuring that vessels registered under its flag comply with the numerous international regulations. However, it is still possible to progress introduction of new technology and IMO's interim guidelines for Maritime Autonomous Surface Ships (MASS) trials – MSC.1/Circ.1604 – makes clear that Flag States have primary responsibility for the safe operation of MASS. Jurisdiction of vessels is determined by the United Nations Convention on the Law of the Seas (UNCLOS).

It's worth stressing from the outset that there are different levels of MASS autonomy ranging from simple decision support tools for shipboard systems through to an operating system that is capable of making decisions entirely without human. intervention. To that end an autonomous ship is not necessarily unmanned but an unmanned ship must be autonomous to a high degree.

The four main pillars of maritime regulation are often considered to be: the International Convention for the Safety of Life at Sea (SOLAS); the International Convention for the Prevention of Pollution from Ships (MARPOL); International Convention on Standards of Training Certification and Watch-keeping for Seafarers (STCW); and the Maritime Labour Convention (MLC).

IMO Secretary General addressing delegates at the 100th meeting of IMO's Maritime Safety Committee in December 2018, which had a particular focus on autonomous ships

SOLAS

SOLAS is the primary instrument for regulating the safety aspects of the design construction and operation of ships. Under its framework ships which embody features of a novel kind may be exempt from any of the provisions of chapters II-1, II-2, III and IV, where the application of those regulations might seriously impede research into the development of such features for ships engaged on international voyages.

However, any such ship must comply with safety requirements which, in the opinion of the Flag State it registers with, are adequate for the service it is intended for and that are deemed acceptable to the Governments of the States which may be visited by that ship. This does effectively restrict these exemptions to a small number of vessels but can be used to assist with the development of new technology.

The 'equivalents' provision is probably the most appropriate method of enabling development of autonomous ships. IMO issues guidelines for the appropriate way of assessing equivalence such as; MSC.1/Circ.1212 Guidelines on alternative design and arrangements for SOLAS Chapters II-1 and III. These guidelines serve to outline the methodology for the engineering analysis required by SOLAS regulations II-1/55 and III/38 on alternative design and arrangements, applying to a specific engineering or life-saving system, design or arrangements for which the approval of an alternative design deviating from the prescriptive requirements of SOLAS chapters II-1 and III is sought.

SOLAS's Construction chapter allows some flexibility in the application to allow exemption for vessels which, in the course of their voyage, do not proceed more than 20miles from the nearest land. The move towards goal based methodologies rather than completely prescriptive ones also helps with the increasing use of autonomous systems.

Machinery and electrical installations respectively have requirements mainly based on relatively traditional arrangements although again there has been sufficient flexibility to allow the development of things such as azimuth propulsion and the ongoing work to enable alternative fuel systems. Automated systems are being utilised for performance monitoring and optimisation, much of this in addition to the prescriptive requirements, thus there is more flexibility in development.

There have been trends to make much more technical information available to officers on the bridge, with periodically unattended machinery spaces helping to

lower operating costs. But with the possibility of periodically unattended bridges (the B0 concept) the opposite could occur, with many current navigation functions being conducted from the engine control room.

The Lifesaving Appliances (LSAs) chapter is another where flexibility has been exploited. Decreasing crew numbers will inevitably lead to changes in the provision and type of LSAs and ensure that they are appropriate for the persons envisaged to be onboard; e.g. if technicians have to be embarked to make and verify repairs.

There have been significant changes to radio communications as technology has improved the ability to transmit vast amounts of data. Ensuring robust and secure communication systems is of course one of the key factors in the safe development of autonomous systems.

The carriage of cargoes is an area where automated monitoring will need further development and there may well be varying levels of public acceptance of the types of vessel that are permitted to operate without a traditional crew, particularly passenger ships and tankers/gas carriers.

SOLAS also covers management for the safe operation of ships and brings into force the International Safety Management (ISM) Code. The Master's Responsibility and Authority is covered, but if we reach the stage of unmanned ships who should be designated the ship's Master and where are they located? However, because the ISM Code only gives a broad overview of what is required rather than prescriptive requirements there is little restriction on development of autonomous technology and developing predictive maintenance programs which could optimise the carriage of spare parts and effective utilisation of skilled personnel. Cyber security is being introduced to the Code.

Maritime security is covered including requirements for ship security alert systems. Shipboard security systems have benefited from modern technology in most areas with better physical security by sophisticated door locking and control systems, CCTV and other monitoring systems will be part of autonomous technology, as of course is the development of secure communication systems so vital for combating the security threats posed. The provision for equivalent security arrangements aids developments of new solutions with respect to autonomy.

MARPOL

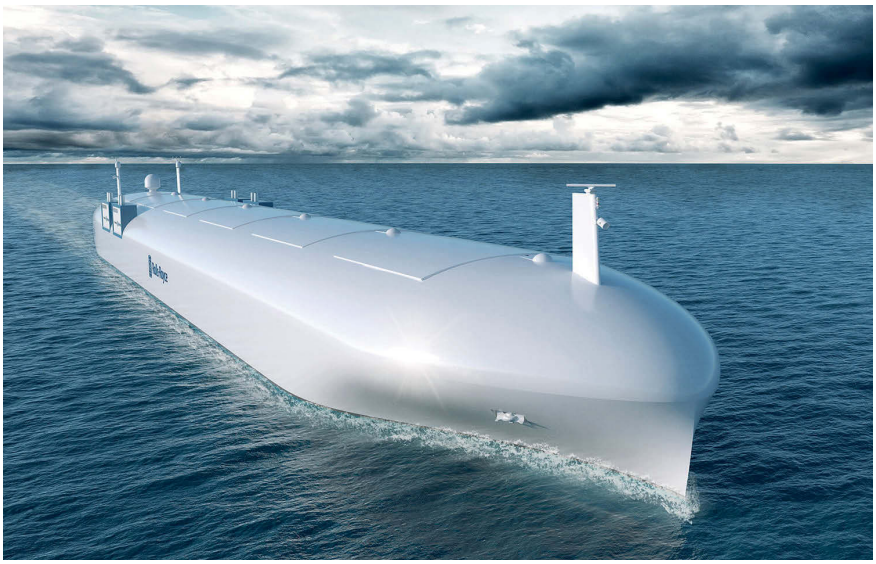
Although there are fewer exemption provisions in MARPOL compared to SOLAS, Annex I regulations for prevention of pollution by oil, does contain exemption provisions at Regulation 3. This is useful for permitting the development of ships using alternative means to those mainly prescriptive ones in the Annex. It also contains unified interpretations which give more specific detail of various issues. Waivers may be granted to certain vessels on certain voyages.

The layout and equipment is reasonably tightly controlled and technology is increasingly useful for ensuring compliance by helping the operators to determine vessel condition especially in the event of damage and improving equipment monitoring for alarm conditions and shutdowns. The use of electronic log books and records is becoming more widely accepted for this and other annexes of MARPOL, these systems of course lend themselves far better to automated operations.

Annex II regulations for prevention of pollution by noxious liquid substances in bulk has similar equivalence provisions. There are none for Annex III (prevention of pollution by harmful substances carried by sea in packaged form), however Annex IV (prevention of pollution by sewage) discharge monitoring offers some scope for increased automation and more accurate monitoring. Similarly Annex V (pollution by garbage), while offering no exemptions or equivalences, is seeing technological advances help in areas such as reducing garbage production and then optimising its treatment.

Annex VI (prevention of air pollution from ships) does have exemptions and equivalents provisions for the purpose of allowing trials for the development of ship emission reduction and control technologies and engine design programs under certain provisions. This is helpful for the development of solutions related to autonomy. There is also the option of exempting certain emissions from seabed mineral activities, which utilise remotely operated and autonomous vessels as with hydrographic activities.

Furthermore, there is provision for any fitting, material, appliance or apparatus if such compliance methods are at least as effective as that required by the Annex. The whole area of improving energy efficiency of ships is greatly aided by improving technology and automation to optimise performance. Ensuring and enforcing compliance with world-wide regulation will also utilise new technology to monitor compliance, increasing demand for accurate sensors and complex analysis of data.



The B0 concept – for periodically unmanned bridges – could ultimately lead to designs which dispense with manned navigation entirely

The implementation of the Electronic Chart Display and Information System (ECDIS) proved a regulatory challenge but is now mandatory on all large ships

STCW

STCW is primarily concerned with training and qualification standards for merchant seafarers. It includes a section on use of simulators, where developing technology comes to the fore as data received from real situations with vessels is vital to enable the necessary modelling for simulators. Technological advances and progress towards autonomy will need development of both the existing requirements and amendments to accommodate the changing roles of personnel.

Navigational advances such as ARPA and ECDIS, are covered in the chapter on the Master and Deck department, while retaining a requirement for traditional skills such as use of sextants. However, if the location of some or all of these functions moves then amendments will be necessary to enable practical application.

The Engine department chapter is another which has been updated to cover automation and the introduction of electro technical requirements to reflect the growing significance of this role, which has considerable importance in ensuring the developing autonomous systems are properly supported.

Radio Operators covers the minimum standard of competence for GMDSS radio operators at the operational level. The widespread removal of dedicated Radio Officers is a good example of how the roles of seafarers have changed with the onset of improved technological solutions.

The chapter on alternative certification does allow for certification systems to keep up with technological developments where different skillsets may get combined in a non-traditional manner. This provides opportunities for effective introduction of autonomy, although it does state that the principles of the regulation shall ensure that the competency of both deck and engineer officers is maintained, which could be interpreted as being a bit restrictive.

Finally, the Watchkeeping chapter covers fitness for duty and watchkeeping arrangements with the principles to be observed. There is ongoing research into the best ways to combat fatigue and ensure that working arrangements optimise seafarer performance. The subject of keeping a proper watch and lookout is one that presents challenges to the development of more automated vessels, especially autonomous ones, and if vessels only need to be manned for certain proportion of their voyage the traditional thinking of watchkeeping arrangements will need to be revisited.

MLC

The tripartite (Government, Ship owners and Seafarers Unions) arrangement for consultation regarding changes in this Convention may be seen, by some, as having potential for slowing development due to concerns on job losses etc. Progress towards unmanned ships will raise new challenges, such as those presented by ships which are autonomous for part of the voyage and then manned for arrivals and departures.

This can potentially give rise to Health and Safety concerns regarding embarking/disembarking persons for events such as coastal passages and port entry. New personnel transfer solutions have already been seen in the offshore sector. Technology, much of it automated, can improve Seafarer comfort by reducing noise and vibration as well as stabilising vessel movement. One possible downside of taking people off ships is that currently there is at least an element of Seafarer self-preservation which helps to preserve assets by preventing casualties.

COLREGS

Rule 1 (e) of the Convention on the International Regulations for the Prevention of Collisions at Sea (COLREG) allows a vessel of special construction or purpose to deviate from the provisions of any of these Rules with respect to the number, position, range or arc of visibility of lights or shapes, as well as to the disposition and characteristics of sound signalling appliances provided arrangements are as close as possible to compliant.

This gives flexibility for developing ship designs. Rule 5 states that every vessel shall at all times maintain a proper lookout by sight and hearing, as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision. But maybe, with appropriate technology, this could also be done by an operator ashore or even eventually autonomously?

Compliance with Rule 7 (risk of collision) and Rule 8 (action to avoid collision) has been aided by the development of radar systems, while computer developments enable optimal solutions to avoiding collisions to be found, which should reduce the deviations from optimum passage speeds and courses. However, care is needed in ensuring suitable parameters are always applied

Other conventions

With regard to autonomy there are numerous supplementary IMO conventions of significance. The International Convention on Load-lines (ILL) has similar provisions to SOLAS, which enables the development of new technology within the guidelines of the existing convention.

Whilst many ballast water treatment systems are quite automated there is usually still need for human intervention for such things as filter changes or lamp changes in ultra violet treatment systems, so there may be need for more backup systems if humans are removed, which would entail amendments

to the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM).

The use of drones for SAR is already being developed as are various devices to enable remote casualty recovery, which influences the International Convention on Maritime Search and Rescue (SAR).

There are a number of conventions covering liability and compensation, such as the International Convention on Civil Liability for Oil Pollution Damage (CLC); the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea (PAL); the Convention on Limitation of Liability for Maritime Claims (LLMC); the International Convention on Civil Liability for Bunker Oil Pollution Damage and the Nairobi International Convention on the Removal of Wrecks (WRC).

These, and the enabling legislation, are of course based on the assumption that vessels are manned, if this is not the case then some of the terminology will probably need modification. There are bound to be errors in autonomous system programming and where the liability lies in these cases will need to be determined to establish who needs appropriate insurance coverage.

The use of autonomous for SAR operations is expected. Image: Sea Machines Robotics

Navigation

SOLAS chapter (V) has a widespread application to almost all ships. Individual ships may be granted exemptions or equivalents of a partial or conditional nature, when any such ship is engaged on a voyage where the maximum distance of the ship from the shore, the length and nature of the voyage, the absence of general navigational hazards, and other conditions affecting safety are such as to render the full application of the chapter unreasonable or unnecessary, provided that the Administration has taken into account the effect exemptions and equivalents may have upon the safety of all other ships.

Navigational equipment has already benefitted from many technological developments, especially e-navigation, with a view to improving the efficiency of the whole maritime shipping operation. The development of integrated bridge systems has been an area of greatly improved human-machine interface, however there are still few fully integrated systems in existence which can still cause frustration to the users and associated risks. Ergonomics and also the dangers associated with information overload have not always been properly addressed.

The carriage requirements for such items as; Automatic radar Plotting Aids (ARPA), Automatic Identification Systems (AIS), Bridge Navigational Watch Alarm Systems (BNWAS), Long Range Identification and Tracking (LRIT), Electronic Chart Display and Information System (ECDIS) have all presented challenges at the implementation stage with stringent specifications being necessary to ensure compatibility and safe operation.

Aids to navigation, ships routing and weather routing services are amongst the areas where technology developments have aided the promulgation and presentation of information to mariners and improve the overall efficiency of transportation. Search and rescue distress signalling etc. are areas where improvements have been made to help if things do go wrong.

Hydrographic activities are already an area where autonomous vessels as well as remotely operated ones are being used to an increasing extent. As these develop from relatively small boats so will the need to further accommodate these developments within regulation.

B0 – conditionally and periodically unmanned bridge possibilities – could well eventually develop to enable moving navigational functions away from the traditional location onboard, and possibly removing it entirely. This could potentially lead to reduction in superstructure heights and aerodynamic improvements.

Sound reception systems are already accepted on enclosed bridges. CCTV already permitted on some vessels for covering blind spots and assisting berthing, as have berthing radars. Whilst care is needed in ensuring that human interpretation of information presented on screens does not deceive the eyes, there is great potential for more optimal positioning of optical sensors leading to reduced lookout needs. The ever-increasing reality of ship simulators is a good indication of what can be achieved.

There should be at least two independent means for all measurement and situational awareness technologies, with proper monitoring and diagnostics of all navigation sensors and equipment. Such requirements should lead to the navigation of ships being conducted in a manner at least as safe as currently exists.

When introducing technology there is obviously a need to ensure that safety is not compromised, however it is also necessary not to introduce too onerous requirements that are in excess of those currently expected of humans performing the function.

Conclusion

There is plenty of opportunity for development of autonomous ship solutions within the constraints of the current conventions all of which will help promote the shipping industry as a vital part of International Trade which is safe, economically viable and environmentally friendly.

About the author

Christopher Balls is principal surveyor for the Cayman Registry. The views in this article are those of the author and not necessarily those of his employer.

This article is an adaptation of a paper originally due to be presented at RINA's Autonomous Ships conference in April 2020. *NA*

Monohakobi Technology Institute adds momentum to One Sea

Monohakobi Technology Institute (MTI), the R&D subsidiary of Japan's NYK Group, offers detailed insights into its participation in One Sea, the global shipping and digital technology leadership group

One Sea, the pan-industry global alliance focusing on autonomous ships, continues to attract leading names from the global digital, communications and ship technology arenas. One of its newest members is MTI (Monohakobi Technology Institute), which is "adding more momentum to our ecosystem development and bringing with it the benefits of many years of acclaimed international maritime R&D," according to One Sea Chairman, Capt Eero Lehtovaara.

MTI, which joined the One Sea Alliance in 2019, was established in 2004 and has a successful track record in international collaborative projects focused on ship efficiency, automation, decarbonisation and data management. Dr Hideyuki Ando, senior general manager at MTI, describes its favoured approach as 'manned autonomous'.

"Our project has been led by ship captains, but they are looking at autonomy as a support," he says. "We believe that 'manned autonomous', based on highly automated systems supporting human operations, will be the best option in terms of safety.

'Manned automated'

"We recognise the positives and the negatives connected to the human element," says Dr Ando. "Human beings suffer from fatigue, can become distracted by other tasks and sometimes lack full situation awareness. But they are flexible and can give deep thought, weighing up options. Humans and machines have different characteristics and our captains are considering the combination of the two. We believe that we can reduce incidents, such as collisions, by introducing such man-machine collaboration and this would be economically attractive compared with traditional ship operations."

In a 2019 presentation at BIMCO's Autonomous Ships Seminar in Copenhagen, Dr Ando and the head of NYK captains, Capt. Tomoyuki Koyama, NYK Line's Managing Corporate Officer, revealed the results of financial analysis of ship automation options. They indicated that, per year, a 'manned autonomous' operation would be about 20% less costly than the conventional non-automated ship in operation today; an 'unmanned autonomous' operation, on the other hand, would double annual costs, whilst a ship involving 'remote operation' would be more than four times as expensive.

Dr Hideyuki Ando, senior general manager, MTI

"Today's technology is not yet sufficiently mature to achieve full autonomy," Dr Ando said. "For example, about 70% of the ship collisions that we have analysed have been caused by a lack of situational awareness on the part of human beings. However, we think that could also happen if a computer were not able to identify every potential hazard from the radar, video or lidar sensors. If the weather conditions are very bad, for example, with very high waves, the sensors and image processing may not be perfect and therefore we may not be able to rely on completely accurate situational awareness."

Data collection standards

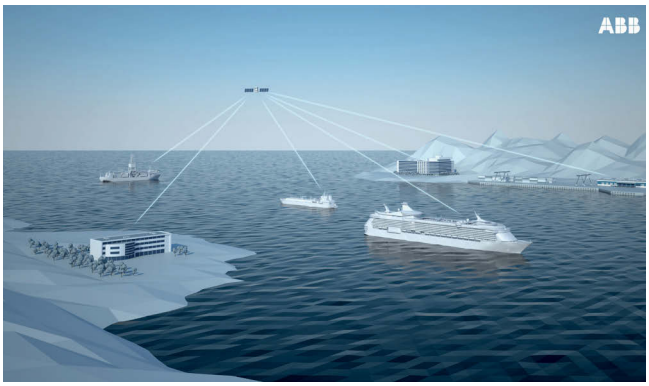
NYK and MTI have developed their own data collection standards internally and all NYK ships today use a Ship Information Management System (SIMS) which provides data to the cloud, supported by operations personnel and technical analysts ashore. Dr Ando acknowledges that many other shipping companies have been making similar moves, but he believes there should be a collaborative approach.

"We are a shipping company – that is our core business. How to collect data safely and effectively is not a place to compete. NYK Group is aiming to define a manned-autonomous system framework called Action Planning and Execution System (APExS) and to clarify its requirements through open dialogue.

"We must have a common understanding of requirements for each component, interfacing equipment, acceptable protocols and which data should be transferred. We have already talked about this at the One Sea meetings that we have attended so far, but we are looking forward to discussing these issues in more detail at forthcoming workshops."

Dr Ando cites another project, funded entirely by the Japanese government, in which the risks and hazards relating to autonomous vessel operation are identified. The three-year project, involving a tug belonging to NYK subsidiary, Wing Maritime Service Corporation, has most recently involved remote operations in Tokyo Bay.

Dr Ando explains that technology is not the main point of this trial. The objective is to establish the requirements that need to be met in an autonomous ship system, bearing in mind upcoming discussions at the IMO on autonomous ship related regulations. Comprehensive appraisals were undertaken, including hazid, failure mode and effects analysis (FMEA), factory acceptance tests and harbour acceptance tests.



One Sea is aiming to achieve an autonomous maritime ecosystem by 2025

Global collaboration

MTI has a consistent track record of cooperating on research projects with international companies. It has worked on several ship performance projects and safety operation projects with Maritime Research Institute Netherlands (MARIN) and was an early adopter of vessel data exchange, using DNV GL's Veracity open platform.

A current long-term research project with Tromsø-based Dualog, a communications company, and supported by Innovation Norway, involves the development of digital systems and services on board 50 NYK vessels, prior to a fleet-wide roll-out in the future. The project, known as Cepa Shield, aims to ensure data transfer efficiency and cyber protection in ship-shore communications, both in-house and with third party managers and OEMs and is expected to run until the end of next year.

In the NYK Super Eco Ship 2050 project, MTI worked with Finland's Elomatic to develop a concept design for an emissions-free pure car carrier. Following earlier work on a futuristic container ship design by the same parties in 2009, the energy demand for the car carrier is approximately 70% less than current designs and CO_2 emissions have been completely eliminated.

Dr Ando stresses the importance of a collaborative approach to data collection and sharing. In this respect, One Sea's global agenda and its focus on standardisation relating to automated ships is likely to benefit from MTI's considerable experience in the development of data collection standards and protocols, now embodied in ISO standards 19847 and 19848. *NA*

Japanese shipbuilding at a crossroads

The Naval Architect takes a look at the current state of the Japanese orderbook and recent deliveries, amid speculation that a shipyard megamerger could be imminent

Although Japan appears to have long since been reconciled to occupying a distant third place to China and South Korea among the biggest shipbuilding nations, the trend towards consolidating interests in the form of shipyard megamergers is a threat that it could ill afford to ignore.

In October 2019, after years of speculation, it was announced that China State Shipbuilding Corp (CSSC) and the China Shipbuilding Industry Co (CSIC) had finally been given approval to merge by the Chinese government. Each company holds 10 separate yards and between them would account for some 20% of the global shipbuilding market. Meanwhile in South Korea the merger between Hyundai Heavy Industries (HHI) and Daewoo Shipbuilding and Marine Engineering (DSME), which was formally agreed in March 2019 could, if it gains approval, account for a further 20% of the global orderbook.

Japan has been at the forefront of efforts to scupper the HHI/DSME merger, taking its case to the World Trade Organization (WTO) once again in February on the grounds that it violates WTO competition rules. However, there is evidence to suggest this may be in part a stalling tactic while it considers its own shipbuilding strategy. In March, Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) revealed it was in preliminary discussions with a number of domestic yards about the possibility of integrating as many as 15 major yards under the so-called All Japan Shipbuilding merger plan.

In many respects such a step could be seen as the logical endgame in a trend towards consolidation that's been apparent for a number of years. With an ageing workforce and engineering expertise increasingly at a premium there are obvious advantages in pooling resources. In 2013, the shipbuilding interests of JFE Holdings (Universal Shipbuilding) and Ishikawajima Heavy Industries (IHI) merged to create Japan Marine United (JMU).

LNG carrier *Bushu Maru*, jointly owned by NYK and JERA Co, was delivered last year

The following year, Sasebo Heavy Industries became a wholly owned subsidiary of Namura Shipbuilding in a US$234 million deal. In 2016, Mitsubishi Heavy Industries (MHI) began discussions which led to a series of commercial alliances with Imabari Shipbuilding, Namura Shipbuilding and Oshima Shipbuilding, covering areas such as development of new ship designs and innovative technologies, sharing of designs and workforce, and standardisation of engineering tools and fitting equipment.

Elsewhere, Fukuoka Shipbuilding's acquisition of Watanabe Shipbuilding and Usuki Shipyard, both on Kyushu Island, made it the dominant builder in Japanese chemical tanker construction. Tsuneishi Group, by contrast, has taken a different approach by forging partnerships overseas which have led to the development of facilities in China, Peru and the ongoing success of its yard in Cebu, the Philippines, which recently celebrated its 25th anniversary.

Then in November last year came the news that Imabari and JMU, generally reckoned to be Japan's two biggest shipbuilders, were forming an alliance, although Imabari in particular have been keen to stress there are no plans for an actual merger. Under the agreement Imabari acquired a 30% stake in JMU, which had approached a number of Japanese shipbuilders about a partnership. By March the two companies had announced the formation of a joint company, Nihon Shipyard Co, which will commence operations on 1 October.

LNG carriers

The new venture will build a variety of vessels including cargo ships, tankers and vehicle carriers. Notably, LNG carriers are not included under the plans, a sector being aggressively focused upon by the South Korean yards. JMU incurred heavy costs and delays during the construction of a series of four 165,000m^3 capacity carriers built for Mitsui OSK Lines (MOL), Tokyo LNG Tanker and NYK Line delivered between 2017 and 2019: *Energy Liberty*, *Energy Glory*, *Energy Universe* and *Energy Innovator*. Built with the self-supporting, prismatic-shape IMO Type B(SPB) storage system first developed by predecessor company IHI Marine in the late eighties, which is claimed to offer superior space efficiency compared to membrane or Moss systems, but at a premium that appears to have deterred any further interest.

Imabari delivered a pair of 178,000m^3 ME-GI-powered LNG carriers to Spanish operator Elcano in 2018. More recently it collaborated with Mitsubishi Heavy Industries (MHI) on a joint venture, MI LNG Co Ltd, which in March and September of last year delivered two 177,000m^3 vessels. *Marvel Heron* and *Marvel Crane*, for MOL, were constructed at Mitsubishi Heavy Industries Marine Structure Co, but drawing upon Imabari's expertise in cost-competitive design.

The Moss-type pair will spend their working lives on a trans-Pacific route via the Panama Canal, delivering gas from the Cameron LNG terminal in Louisiana to Japan, a project in which Japanese companies have a sizable interest. They joined the 155,000m^3 *Marvel Eagle*, delivered by Kawasaki Heavy Industries (KHI) in September 2018, with the fourth of the quartet, *Marvel Pelican*, also coming from KHI at the end of last year.

MHI also delivered a further three LNG carriers in its Sayaringo STaGE [Steam Turbine and Gas Engine] class vessels, a series of next generation Moss-type storage system that was an evolution of its successful Sayaendo series. The apple-shaped 165,000m^3 capacity tanks and twin-shaft hybrid propulsion system debuted on *Diamond Gas Orchid* (2018), which has since been joined by *Diamond Gas Rose* (2018) and *Diamond Gas Sakura* (2019), all jointly owned by Mitsubishi Corp and NYK Line and again serving the Cameron LNG project.

A further three Sayaringo STaGE vessels were built for the Texas Freeport LNG project: *LNG Juno* (2018), *Noshu Maru* (2019) and *Bushu Maru* (2019). But in December MHI announced it was selling the Koyagi plant in Nagasaki, where many of these vessels were constructed, to Oshima Shipbuilding.

Japan is famously dependent on imports for the vast majority of its energy supply, with the government revealing last September that it intends to invest US$10 billion in overseas LNG infrastructure projects around the world over the coming years. However, there are are no LNG carriers currently on order at Japanese yards and it has been reported that when Qatar Petroleum began inviting tenders for a new fleet of over 100 LNG carriers it is expected to place later this year, Japanese yards felt unable to compete with the Korean shipbuilders given the Qatari requirement for membrane-type systems.

LPG and tankers

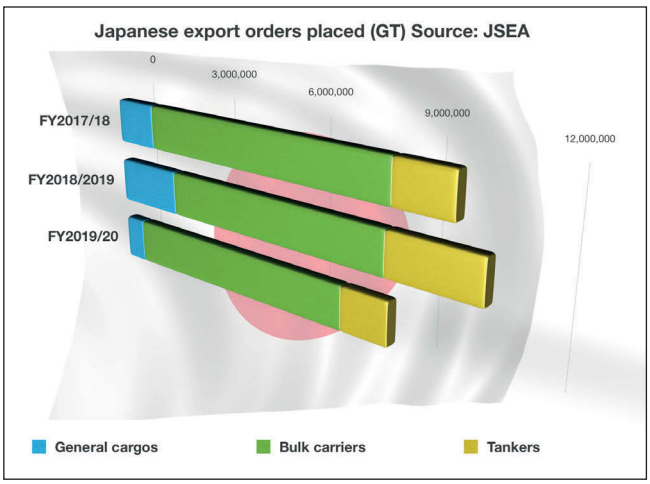
Although the Korean yards are also enjoying the lion's share of orders for LPG carriers, the Japanese continue to retain some limited interest in this sector, albeit largely in the way of domestic orders. According to figures published by the Japan Ship Exporters Association (JSEA) six gas carriers were ordered from Japanese yards during the last financial year, with Kawasaki Heavy Industries (KHI) securing two notable bookings from Singapore-based Kumiai Navigation. In January, KHI celebrated the delivery of its 60th LPG carrier, *Phoenix Gaia*, for Singapore's Phoenix Tankers. It's the 11th vessel in its class to use the proprietary Sea-Arrow bow shape for minimising resistance.

Also noteworthy is *Hourai Maru*, delivered by Namura Shipbuilding in March last year from its Imari facility. The 38,000m^3 capacity fully refrigerated LPG carrier is the first to incorporate adapted IMO Type B independent prismatic tanks, which both improve safety performance and allow for easier maintenance due to the partial secondary barrier of low temperature steel. As well as being equipped to carry various products including commercial propane, anhydrous ammonia and vinyl chloride monomer, it was also the first to be awarded ClassNK's SMARTShip notification for the varying degrees of autonomy of its onboard systems.

Meanwhile, in October NYK Line took delivery of its first scrubber-fitted ships, the 310,000dwt *VLCC Tanzawa*, built at JMU's Kure yard. It is in fact the eighth in the eco-type Malaccamax VLCC series developed after the merger of Universal Shipbuilding and IHI Marine. Optimised for transportation between the Middle East and Japan, and said to be 23% more energy-efficient, technologies include the Super Stream Duct, Surf-Bulb and ALV-Fin, as well as the patented Leadge-Bow.

But perhaps of greater long-term significance was the launch of *Suiso Frontier*, the world's first liquified hydrogen carrier, at KHI's Kobe shipyard in December 2019. Japan's ambitious plans for a hydrogen-based society requires an abundance of unused and renewable

In March, the liquified hydrogen storage tank was installed onboard *Susio Frontier*. The vessel is expected to enter service early next year



Dry cargo continues to dominate Japanese shipbuilding

energy to be chemically transported from overseas, in particular Australia. When it finally enters service in 2021, *Suiso Frontier* will transport liquified brown coal-derived H2 9,000km from the Port of Hastings to Kobe, where it will be unloaded.

The vessel will shortly be fitted with a 1,250m^3 vacuum-insulated, double-shell-structure liquefied hydrogen storage tank manufactured at a nearby plant of Harima Works, something which KHI says will draw heavily upon its experience with the cryogenic requirements of LNG. However, *Suiso Frontier* is essentially a test project apropos to developing a much larger design of 160,000m^3 capacity by the middle of the decade.

Data released by Clarkson Research earlier this year indicated that Japanese orders during 2019 amounted to 3.28 million in compensated gross tonnage (cgt), or 13% of the global orderbook of 25.29 cgt; compared to South Korea (9.43 million cgt – 27.3%) and China (8.55 – 33.8%). When expressed in terms of value, the Japanese orderbook of US$6.1 billion is nudged down into fourth place by Italy's cruise shipbuilding industry.

The global orderbook shrank by almost a fifth during 2019, but there are troubling signs that Japanese shipbuilding may be shrinking even faster, with a tonnage ordered during the 2019/20 fiscal year only 79% of 2018/19, according to figures published by JSEA. The brunt of that damage is being suffered by tankers orders, which have almost halved with only 24 bookings and an aggregate gross tonnage of 1,258,026. During the same 2018/19 period 58 tankers were delivered at 4,014,301gt.

Boxships and bulkers

Only eight orders were placed at Japanese yards for container ships last year and it was a sadly too-familiar story as Imabari missed out to Chinese and South Korean rivals when Evergreen placed orders for 11 23,000TEU vessels. It was a blow given that a few months earlier its Saijo had delivered the similarly sized *Ever Glory*, which was not only the operator's first newbuilding installed with scrubbers, but triumphantly arrived in Rotterdam on its maiden voyage in June fully loaded with green Evergreen containers. However, Imabari does have a further 10 in the 20,000TEU F-class series due for delivery to Evergreen over the next two years.

Dry cargo shipbuilding remains the staple diet of the Japanese yards and comprises three quarters of the vessels ordered last year and two thirds of deliveries, according to JSEA figures. Arguably it is the one sector in which they are still able to compete favourably with South Korea and China, albeit in a slowing market. Orders include NYK Line's booking for the J211 BC from JMU, an upgrading of JMU's previous Newcastlemax G-series 209 design offering improved deadweight for similar dimensions.

Elsewhere, Tsuneishi Shipbuilding secured the first order for its TESS42 design log and bulk carrier. As with JMU, the design is an evolution of an existing model, in this case the TESS38, with four deck cranes, wide-opening hatch covers, and semi-box-type cargo holds suitable for transporting steel products. However, it also offers improved capacity and will feature an electronically controlled engine that reduces fuel consumption by around 4%.

Until the Covid-19 pandemic changed plans, Oshima Shipbuilding had been organising to host an unusual quadruple naming ceremony in March for four of the five vessels it had under construction for Oldendorff carriers. Three of the vessels – *Beate Oldendorff*, *Benjamin Oldendorff* and *Britta Oldendorff* – were built to the Oshima-62k design, while the 100,000dwt post-Panamax *Dietrich Oldendorff* is a new design said to feature the most economical hullform for its size class. Delays notwithstanding it will be joined by the second in the series, *Diane Oldendorff*, in June.

Japanese yards are also at the forefront when it comes to developing new eco bulker designs, such as Sanoyas Shipbuilding's LNG-fuelled woodchip carrier, which recently obtained an AiP from ClassNK. Designed to achieve a 40% improvement on current EEDI requirements, the LNG fuel tank would be installed on the stern deck behind the superstructure to maximise cargo capacity. Sanoyas, which already has considerable experience developing pressurised LPG storage tanks, recently announced it was launching a gas supply system and support engineering service for LNG fuelled ships.

It should be stressed, of course, that while larger merchant shipbuilding has declined in Japan there is vibrant research and development with regard to autonomous ships and electric propulsion. Last August, e5 Lab Inc, a joint venture between Asahi Tanker, Exeno Yamamizu Corp., MOL and Mitsubishi, announced it was planning to build a 60m 499gt zero-emission battery-driven coastal tanker that will operate in the Tokyo Bay from 2021. If successful it should follow Norway's much anticipated *Yara Birkeland* as the second major all-electric vessel in operation.

Mitsui and MOL are also fronting a consortium, with the support of the Japanese Ministry of Land, Infrastructure, Transportation and Tourism, which aims to have autonomous ships in operation in Japan by 2025. ***NA***

Swedish operator's MegaRoRo begins construction

Wallenius SOL's inaugural vessel orders, now under construction in China, will be both the world's largest LNG-fuelled and ice-classed ro-ro's

With much of the world on the brink of Covid-19 lockdown in late March, the CIMC Raffles shipyard in Yantai hosted a steel cutting ceremony for what will become the world's largest LNG-powered ro-ro upon delivery. The 242m long, 35.2m wide MegaRoRo vessels, which will have a maximum speed of 20knots, 27,000dwt, and 5,800LM capacity will also be the largest ships of their class in the world.

The MegaRoRo will be built to the 1A Super ice classification, allowing it to navigate in ice 100cm thick

The order for two of the new series, which includes an option for two more, is the first to be placed by Wallenius SOL, a joint venture formed by operators Wallenius Lines and Swedish Orient Line (SOL) in April last year. The new company will transport forestry products and other goods around the Gulf of Bothnia, Baltic Sea and North Sea, strengthening the Finnish and Swedish forestry industries, and has already secured commitments from paper and card producers Stora Enso and Metsä Board. One of the principal drivers behind the Wallenius SOL is operational efficiency through sustainable transportation.

To help realise this, the company is investing heavily in new vessels which it believes will reduce its environmental impact. In addition to being LNG fuelled and incoroprating other eco friendly features, the new vessels are to be built to Finnish/Swedish ice class 1A Super standard, allowing for year-round operation, even in the Gulf of Bothnia, where the temperature can descend to -35°C and produce hazardous ice banks.

According to Carl-Johan Söder, naval architect at Wallenius Marine, the development of the vessel began with a brainstorming session to consider the size, machinery and ramp systems the ships would require. "We drafted up different concepts in CAD at an early stage. But we also used simpler methods. We built a model of the ships' loading ramps with pieces from a shoebox," he explained.

The particular requirements of the wood pulp and paper industries, such as standard paper cassettes and extra-large containers, were all crucial in determining the ship's initial design, as were optimising fuel efficiency. Wallenius Marine's design team also spent time at Aker Arctic's ice testing facility in Helsinki, where a 7m model was driven through water with artificial ice.

"We tested the vessel's capability to follow and break out from a channel in extreme ice conditions and ability to penetrate thick ice ridges… We have a bulbous bow which cracks the ice from below, and a stern which pushes down ice floes when the vessel turns. This is advantageous when the ships are carrying lighter loads," said Söder.

Other characteristics include a 5m ice-reinforcement belt above and below the waterline, which runs higher and deeper at the prow. Larger bilge keels have been incorporated instead of a flap rudder, given the risk of ice damage to moving parts.

As the concept further evolved, Knud E. Hansen was contracted to develop the specifications for the shipbuilding tenders. In recent years, the Danish naval architecture firm has developed considerable expertise in the large ro-ro sector, working on such projects as the ongoing G5GG series for Grimaldi and a 6,700LM design for DFDS, both of which were built at the CSC Jinling shipyard. But after visiting a number of facilities across the world, the contract was awarded to CIMC Raffles. Plan approval and classification will be undertaken by Lloyd's Register, for eventual registry under the Swedish flag.

In January, the contract to provide the LNG fuel-gas supply systems was awarded to MAN Cryo, MAN Energy Solutions' marine LNG fuel-gas-system manufacturer. MAN Energy Solutions has also been selected to supply 2 × 9L28/32DF dual-fuel auxiliary engines for each vessel. Under the agreement Man Cryo will provide 2 × 685m^3 'Type C' vacuum tanks including tank connection spaces (TCSs) with LNG fuel pumps, bunker stations with a capacity of 500m^3/h and automation, emergency shut-down and gas-detection systems.

Given the harsh conditions the ships will operate in the amount of cold air also needs to be kept to a minimum, so features will include under-deck mounted tanks with air locks to reduce the fresh air that can enter. Meanwhile, Alfa Laval has secured the contract to equip the newbuildings with its UV-based PureBallast 3 ballast water treatment system.

Compared to a standard sized ro-ro operating on HFO, drawing upon research published by the Swedish Environmental Research Institute, it is reckoned the MegaRoRo will bring a 50% reduction in fuel consumption per tonne km, 60% decrease in GHG emissions, 98% SOx, 85% NOx and cut particulate emissions by 95%.

Delivery of the first two vessels is scheduled for the latter part of 2021. *NA*

Damage stability regulations for ro-paxes

Concluding two previous articles published in the May and September 2017 editions of *The Naval Architect* [1, 2] and papers presented at RINA conferences over the past decade [3 to 9] Keith Hutchinson of Safinah Group and Andrew Scott of the Maritime and Coastguard Agency discuss, following the introduction of SOLAS2020 at the beginning of this year, the current status and possible future developments of the damage stability regulations for ro-pax ships

In the 1990's and 2000's fundamental changes to the damage stability regulations for passenger ships contained within the Safety of Life at Sea (SOLAS) convention were considered by the International Maritime Organization (IMO). This involved the deterministic SOLAS90 regulations being replaced by regulations based on probabilistic methods. The aim was to produce revisions to the SOLAS Chapter II-1 damage stability regulations by combining and harmonising the existing probabilistic regulations for dry cargo ships (SOLAS90 Chapter II-1, Part B-1, Regulations 25-1 to 25-10) and passenger ships (IMO Resolution A.265(VIII)) with newly drafted probabilistic damage stability regulations encompassing both dry cargo ships and passenger ships. This eventually culminated in the SOLAS2009 Amendments which entered into force on the 1 January 2009 (IMO Resolution MSC.194(80)) together with the associated explanatory notes (IMO Resolution MSC.281(85)).

Even before the entry into force of SOLAS2009, doubts began to arise as to whether the harmonised probabilistic regulations would result in passenger ships, specifically large cruise and roll-on / roll-off passenger (ro-pax) ships, having an equivalent level of safety to the deterministic SOLAS90 regulations they were replacing. Hence, various amendments were found to be necessary to the regulations and the explanatory notes. Amendments to the regulations were finally approved under IMO Resolutions MSC.421(98), adopted on 15 June 2017, and MSC.436(99), adopted on 24 May 2018, and entered into force on 1 January 2020. Amendments to the explanatory notes agreed since 2009 appear in IMO Resolution MSC.429(98), which was adopted on 9 June 2017, also entering into force on 1 January 2020. In totality, these are referred to as the SOLAS2020 Amendments and it is the damage stability aspects of these which are discussed in this article.

MV Skane leaving Rostock, Germany

SOLAS2020 *s* factor

Work on the ro-pax ship damage stability agenda item spanned over five sessions of the IMO Sub-Committee on Stability and Load Lines and on Fishing vessels (SLF), SLF 51 to 55 between 2008 and 2013, and eventually resulted in a significant change in one of the main probabilistic parameters – the *s* factor – which determines the likelihood that a given damage scenario is survivable in all sea states up to 4m significant wave height, H_S. The *s* factor is derived by calculating residual stability characteristics such as righting lever, *GZ*, range and heel and post-processing these results through an equation which is supposed to predict the probability of survival after flooding of a given compartment or group of compartments. For example, an *s* factor of 1.0 for a given damage scenario implies that the ship will always survive that damage in any random sea state with a H_S of up to 4m. An *s* factor of 0.5 implies that the ship will survive that damage in only 50% of randomised sea states and an *s* factor of zero (0.0) means that the ship will not survive that damage in any sea state.

As can be seen in Figure 1 the changes to the *s* factor in SOLAS2020 for ro-pax ships only, as approved at SLF and later adopted at IMO's Maritime Safety Committee (MSC) (see below for details), makes it more difficult for such a ship to achieve an *s* factor of 1.0 when damaged in way of the garage space on the vehicle deck. This in turn means that the probabilistic Attained Subdivision Index, *A*, being the summation of the products of the *s* factors and *p* factors (the probability that a given compartment or group of compartments will be damaged) for all damage cases over a range of draughts, will be reduced to some degree making it more

difficult for the ship to achieve the Required Subdivision Index, *R*. The changes in the *s* factor specifically for ro-pax ships which were agreed for SOLAS2020, to account for the water-on-deck effect using probabilistic methods, were the introduction of TGZ_{max} (maximum GZ_{max} for ship / damage type) and *TRange* (maximum *Range* for ship / damage type) which are varied for ship / damage type as shown below (extracted from SOLAS Chapter II-1, Part B-1, Regulation 7-2.3):

$$s_{final,i} = K \cdot \left[\frac{GZ_{\max}}{TGZ_{\max}} \cdot \frac{Range}{TRange} \right]^{\frac{1}{4}}$$

where:

GZ_{max} is not to be taken as more than TGZ_{max};

Range is not to be taken as more than *TRange*;

TGZ_{max} = 0.20 m, for ro-ro passenger ships each damage case that involves a ro-ro space, = 0.12 m,otherwise;

TRange = 20°, for ro-ro passenger ships each damage case that involves a ro-ro space, = 16°, otherwise;

$K = 1$ *if* $\theta_e \le \theta_{min}$

$K = 0$ *if* $\theta_e \ge \theta_{max}$

$$K = \sqrt{\frac{\theta_{\max} - \theta_e}{\theta_{\max} - \theta_{\min}}} \quad \text{otherwise,}$$

where:

θ_{min} is 7° for passenger ships and 25° for dry cargo ships; and

θ_{max} is 15° for passenger ships and 30° for dry cargo ships.

These changes in SOLAS2020, which became known as the '20/20' *s* factor, introduced for the first time a distinction between ro-pax ships and conventional passenger ships to reflect the vulnerability of the former to the effects of the ingress of water onto the large open car deck.

SOLAS2020 *R* index

From the research projects underway during 2009 to 2012 doubts began to emerge as to whether the SOLAS2009 Required Subdivision Index, *R*, represented a sufficiently high level of safety. A value for *R* of 1.0 effectively means that any ships achieving this figure would survive all the damage cases in the IMO database up to a length of 60m in any randomised sea state up to 4m H_S. A *R* index of 0.80 means survival of 80% of the damage cases, leaving 20% of the cases non-survivable. For ro-pax ships, 'non-survivable' could mean very rapid capsize in under 30 minutes with very little chance of orderly evacuation and hence a high casualty rate.

Passenger ships in contrast, not being vulnerable by virtue of a large open deck area to rapid capsize, and with a significant but unquantified volume of reserve buoyancy above the bulkhead deck, could survive longer and thus provide a better opportunity for passengers to evacuate in an orderly fashion. For this reason, the United Kingdom (UK) was always more worried about the safety of ro-pax ships than conventional passenger ships such as cruise liners.

To further investigate concerns over the level of *R*, early in 2014, IMO opened a new agenda item on this issue. Independently, a new European Union (EU) research project was started, the outcome of which fed into the IMO debate. As a result, views at IMO slowly shifted towards the need for a substantial increase in the *R* index to try to reduce, as far as economically possible, the number of non-survivable damage cases. This meant that the SOLAS2020 Amendments could no longer be constrained by the need to provide an equivalent level of safety to SOLAS90 (as the SOLAS2009 Amendments had been) and so a decision was taken to unilaterally increase the safety standard of passenger ships, including ro-pax ships, by raising the *R* index to levels greater than those provided by SOLAS90.

For passenger ships, including ro-pax ships, the SOLAS2009 *R* index was derived from a regression formula based on subdivision length, L_S, the number of Persons on Board (PoB), *N*, together with the lifeboat capacity (see below for the formula extracted

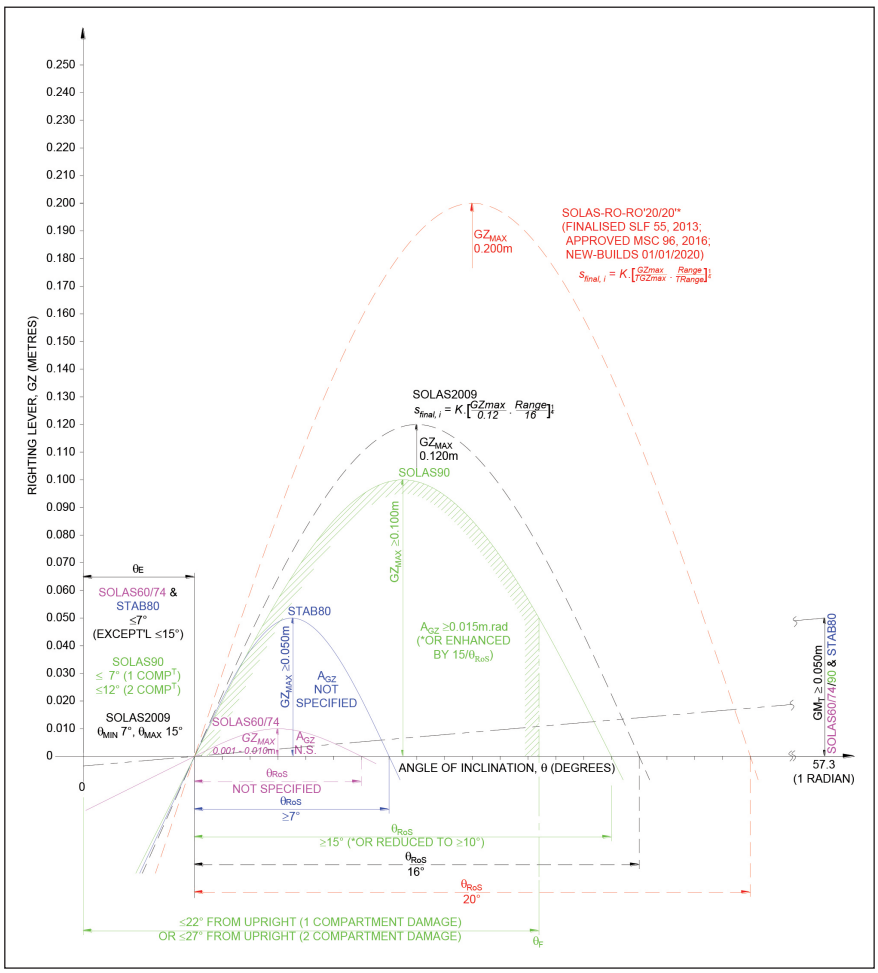


Figure 1: Comparison of damage residual stability standards for passenger ships from SOLAS60 to SOLAS2020 (final stage of flooding)

from SOLAS2009 Chapter II-1, Part B-1, Regulation 7-2.3):

$$R = 1 - \frac{5,000}{L_s + 2.5N + 15,225}$$

where:

N = $N_1 + 2N_2$;

N_1 = Number of persons for whom lifeboats are provided;

N_2 = Number of persons (including officers and crew) the ship is permitted to carry in excess of N_1.

After much research and debate both at IMO and within the EU, a new formula for R for passenger ships, which includes ro-pax ships, was eventually agreed at SDC 3 (IMO Sub-Committee on Ship Design and Construction – formerly SLF to 2013) early in 2016 and shortly afterwards approved for adoption into the SOLAS2020 amendments at MSC 96. The revision to R in SOLAS2020 Chapter II-1, Part B-1, Regulation 7-2.3:

PoB	Required Index, *R*
$N < 400$	$R = 0.722$
$400 \leq N \leq 1350$	$R = N / 7580 + 0.66923$
$1350 < N \leq 6000$	$R = 0.0369^* \text{Ln}(N + 89.048) + 0579$
$N > 6000$	$R = 1 - (852.5 + 0.03875^* N) / (N + 5000)$

where:

N = Total number of Persons on Board (PoB).

It will be noted that R now only depends on N, not L_S or the lifeboat capacity as in SOLAS2009 as it was felt at IMO that it was important to focus on the safety of passengers and not necessarily on the overall size of the ship or the lifeboat capacity. The latter is now determined independently under the SOLAS life-saving regulations in Chapter II-2. There was also the intent of making the R index vary less with the number of persons carried, i.e. to aim for a more horizontal line in the plot of R against N, as it was felt that peoples' lives were equally important no matter how many were actually being transported onboard the ship. For smaller ships, it is difficult to increase internal subdivision for practical reasons and so two knuckles were introduced into the plot of R verses N, as shown in Figure 2.

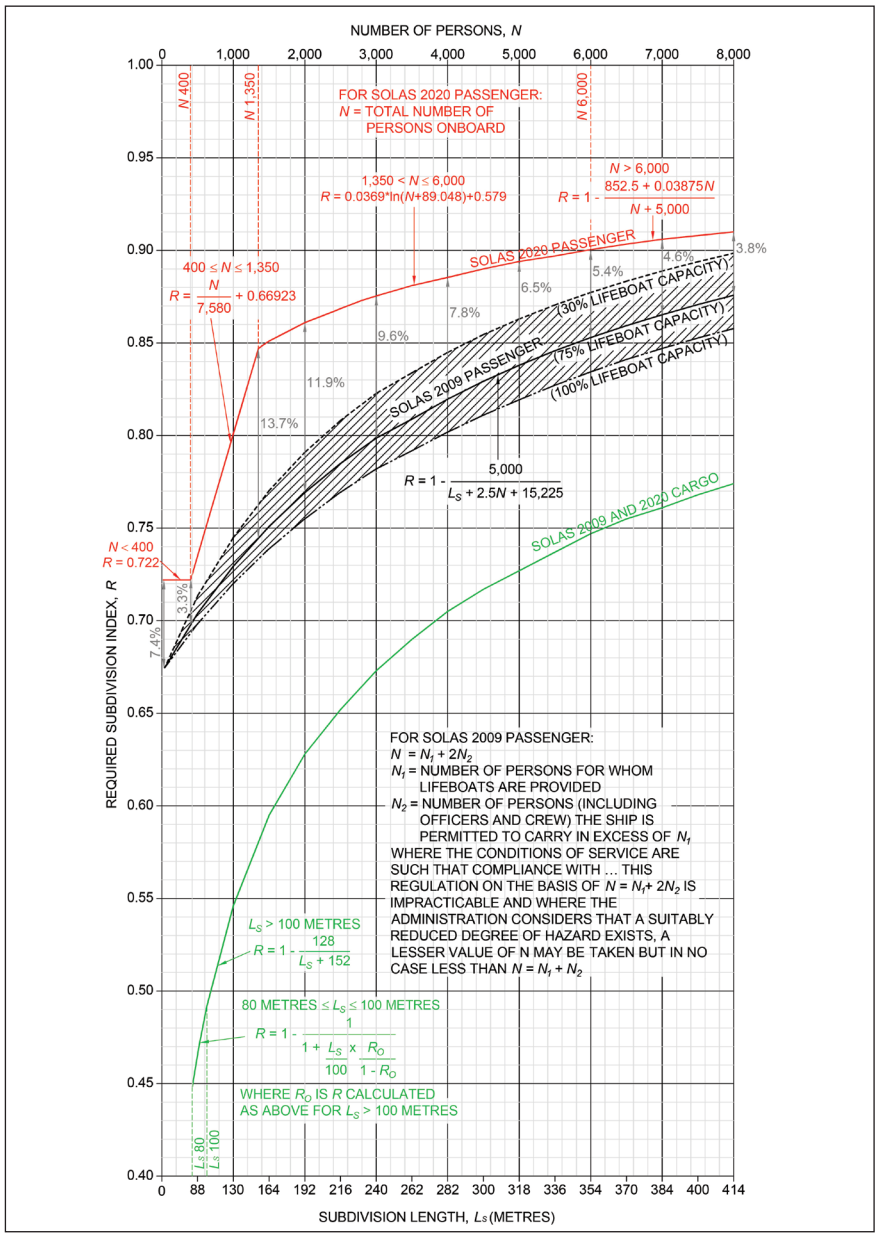


Figure 2: Plots of R against L_S and N to illustrate changes from SOLAS2009 to SOLAS2020

The red line shows the passenger ship R index as amended for SOLAS2020, the black lines being the SOLAS2009 passenger ship lines (depending on the number of persons carried in lifeboats) and the green line the R index for dry cargo ships, which remained unchanged for SOLAS2020 from SOLAS2009.

Stockholm Agreement

Since April 2003 all EU flagged ro-pax ships and non-EU flag ships operating in EU waters must additionally comply with the Stockholm Agreement (EU Directive 2003/25/EC as amended) which was implemented into UK law under Statutory Instrument SI 2004 No. 2884 and Merchant Shipping Notice MSN 1790 (both as amended). This requires compliance with the deterministic SOLAS90 damage stability criteria with an additional quantity of flood water on the damaged vehicle deck. The exact quantity of floodwater assumed to be taken onboard the car deck is dependent upon the residual freeboard in way of the damage opening and the sea-state (up to an assumed maximum of 4m H_S with each sea area within North-West European waters being assigned a figure for H_S. Compliance can be demonstrated either by calculation

or by model testing. It is noteworthy that the Stockholm Agreement was never universally adopted by IMO, remaining a regional agreement to this day, and that few, if any, non-European IMO member states ever voluntarily adopted it.

It was originally intended that these requirements would be revoked on 1 January 2009 but concerns over the safety levels provided by the SOLAS2009 Amendments led to a decision by the EU to retain the Stockholm Agreement to be used in conjunction with the SOLAS2009 Amendments. The current amendments to SOLAS2009 have still not completely allayed the safety concerns. At the time of writing the Stockholm Agreement has not been revoked for new ships constructed on or after 1 January 2020. A decision is to be taken by the EU based on the results of a three-year research project.

Insofar as the future of the Stockholm Agreement is concerned, one view is that the EU should retain it for a few years after 1 January 2020 and require that model tests be conducted on each new ro-pax ship to provide more data on the ability of the new '20-20' *s* factor to predict survivability; its predecessor was rather poor in that respect. If retained, the Stockholm Agreement will continue to have a major constraining influence on the subdivision of ro-pax ships, particularly those fitted with long lower holds (LLHs), since retention of protective B/5 longitudinal bulkheads would be almost obligatory.

Only when all parties are convinced that the various formulations used in the probabilistic damage stability regulations are robust and reliably producing 'safe' ro-pax ships should we have the confidence to allow ship designers to utilise the full freedom provided by the probabilistic method to innovate new and more efficient internal subdivision arrangements.

Future development

Amendments to SOLAS Chapter II-1 and the explanatory notes continue to be made and will enter into force at dates now specified in the text. These post-2020 SOLAS text amendments were approved at IMO's MSC 101 in May 2019 and can be found in MSC 101/24/Add.1 Annex 25. Corresponding amendments to the explanatory notes were proposed by an inter-sessional correspondence group in 2019 and approved at IMO SDC 7, on 3- 7 February 2020, for subsequent adoption at IMO's MSC 102 originally scheduled for this month but now postponed due to Covid-19.

SDC 7 marked the substantive completion of the massive task of converting the SOLAS damage stability regulations for dry cargo and passenger ships (together with the accompanying Explanatory Notes) into a cohesive probabilistic framework which will come

as some relief to the owners and operators of ro-pax ships in terms of planning ahead and optimising new designs.

The UK's Maritime and Coastguard Agency (MCA) is in the process of producing a document entitled '*Instructions for Surveyors – Damage Stability Guidance Manual*' which will be accessible via the GOV.UK website using the reference number MSIS 42. It will be a 'live' document, regularly updated, containing the latest SOLAS Chapter II-1 amendments with explanatory notes and the UK's own interpretation of regulations hitherto left to the 'satisfaction of the Administration'.

Conclusions

The combination of the change in SOLAS2020 regarding the *s* factor for ro-pax ships together with the general increase in the *R* index for all passenger ships, including ro-paxes, will undoubtedly result in safer ships constructed on or after 1 January 2020 but will present a major challenge to designers to ensure their continued economic viability, especially for ships fitted with long lower holds. *NA*

Disclaimer

The views expressed in this article are those of the authors and do not necessarily represent those of the organisations with which they are affiliated and the professional institutions of which they are members.

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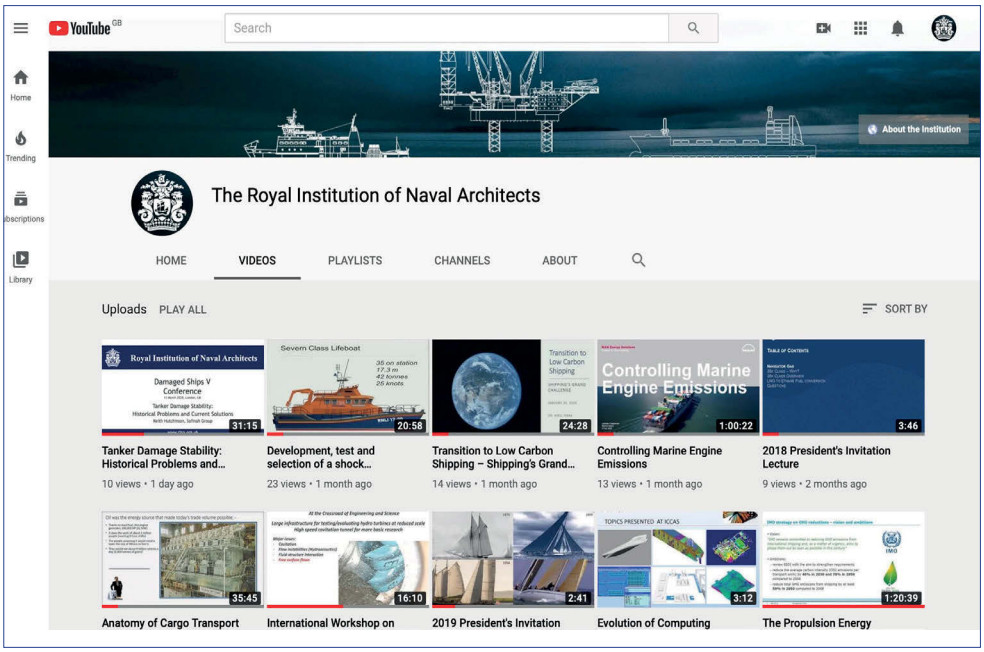

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