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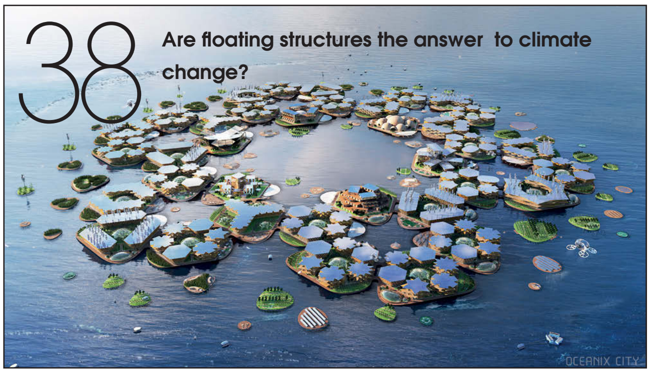

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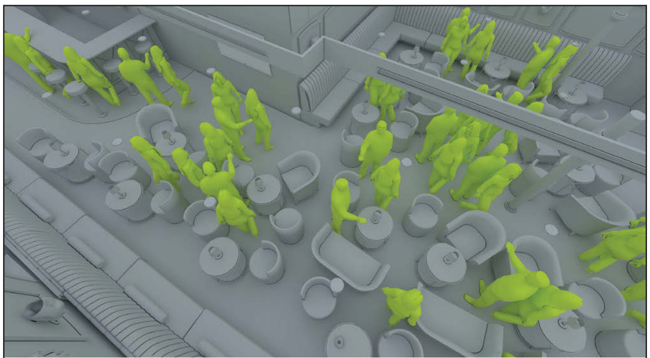

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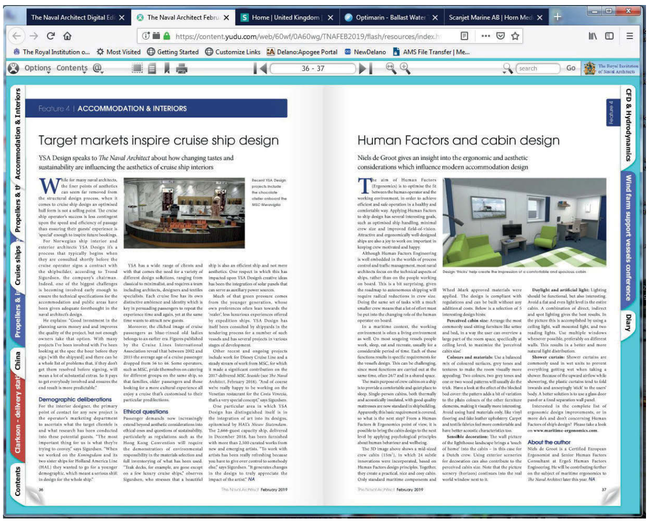


The nuclear elephant

The floating nuclear power station *Akademik Lomonosov* being towed to its permanent location in Russia's Chukotka region in August 2019

Last year, I was editing an article from a well-known shipping analyst looking at IMO's 2050 targets and how they could be achieved. Among the possible alternative fuels he'd included a section on nuclear power , but I suggested to him that it would be better to downplay this for the simple reason that in all the debate I'd never heard nuclear-powered ships seriously considered.

I continue to stand by that if only because nuclear clearly has an image problem. The triple-headed spectre of the Three Mile Island, Chernobyl and Fukushima reactor meltdowns (coincidentally referenced on p.38-39) looms large over the general consciousness, not least because these incidents might have been far worse. And these were stationary power plants – how much more vulnerable might a mobile nuclear reactor be to a lapse in safety or security?

Although nuclear-powered icebreakers have operated in the Russian Arctic since the start of the 1960's, the notion of a nuclear merchant fleet has struggled from the very beginning. NS *Savannah*, the 182m general cargo ship built by the US Government in the 1950's to showcase the potential of atomic energy, proved so costly to operate that it was mothballed in 1972, less than a decade after it began operations.

Of the other attempts Japan's test project *Mutsu* developed problems with its radiation shielding before it ever carried cargo, while the German *Otto Hahn* was retrofitted to diesel propulsion within nine years. Russia had more success with the 1986-launched icebreaking LASH carrier *Sevmorput*, but since spending several years laid up it has operated mainly under the charter to the country's defence ministry for the transport of military equipment in the Arctic.

Yet as thoughts have turned towards emission-free shipping, whether sulphur or carbon, nuclear has started to seem like the proverbial elephant in the room. After all, it's the only proven solution capable of fulfilling our abundant energy demands outside of fossil fuels. Why spend years trying to develop viable renewable sources when the answer is staring us in the face?

Putting aside the disingenuity of that question, there are the first murmurings of an atomic revival. In October, Lloyd's Register's global head of risk management, Vince Jenkins, spoke at the Interferry conference in London about the potential for nuclear-powered ships. Jenkins, who spent 11 years with the UK's Atomic Energy Authority, believes nuclear could be a particularly attractive option for the ferries as it would remove the need for time-consuming bunkering (or battery recharging) when berthed. One factor in this is the development of smaller, more affordable nuclear reactors.

"For the last 10-15 years, reactors have been the focus of the land-based industry, offering power bands of around 10-300MWe. Up to 100MWe is what the marine industry is actually interested in," Jenkins told delegates.

To underline his point, in January a consortium led by Rolls-Royce revealed plans to install and operate 10-15 factory-built mini nuclear power stations in the UK by 2029, to be built (for security reasons) at former nuclear sites. Meanwhile LR, which first published its (since withdrawn) 'Provisional Rules for the Classification of Nuclear Ships' as far back as 1966, has in recent years been providing support to a project in China to build up to 20 floating nuclear power plants.

As has been well documented Russia has beaten them to it, with the controversial non-self-propelled nuclear power barge *Akademik Lomonosov* entering service at the end of last year. Owned and operated by the state nuclear company Rosatom and equipped with two KLT-40 naval propulsion reactors capable of a combined output of 70MW of electricity (or 300MW heat) it is intended as a pilot project that could eventually see similar units providing cheap energy to developing countries in Asia and Africa.

Critics, such as Greenpeace, have suggested *Akademik Lomonosov* is nothing less than a 'Chernobyl on Ice', however, as there are no plans to transport it through international waters, it bypasses the scrutiny of IMO. Furthermore, given nuclear falls outside of the current scope of EEDI, there are no energy constraints in place for ships using this technology.

Jenkins, who gives an interview to our sister publication *Ship & Boat International* in its March/April edition, concedes that public acceptance remains nuclear's biggest hurdle but questions whether, with advances in fail safe mechanisms, the risks are more perceived than real. Although the technologies are completely different, one might draw comparison with the advances made with regulations for low-flashpoint fuels.

In response to interest from clients LR has developed a framework of principles to be considered when exploring nuclear, which take the typical goal-based approach. One can state with a reasonable degree of confidence that the other classification societies are also being consulted about the feasibility. But don't expect nuclear-powered cargo ships anytime soon. *NA*

Hybrid propulsion

World first for Wärtsilä

Wärtsilä has announced it will provide the complete system design and equipment scope for two new 9,300dwt self-discharging bulk carriers, the first of their type to be fitted with a hybrid propulsion system.

Each vessel will be equipped with a Wärtsilä 26 main engine (with gearbox and controlled pitch propeller), DC switchboard, battery pack, and power management system. They are being built at the Netherlands-based Royal Bodewes shipyard for Norway's Aasen Shipping.

Prior to hiring Wärtsilä to equip the new vessels, shipowners Aasen Shipping contacted the technology company to confirm whether such a hybrid installation would benefit its new bulk carriers. The companies' collaborative study confirmed that the increased initial investment required for battery installation would be significantly offset by the fuel cost savings.

Moreover, Enova SF, the Norwegian government enterprise responsible for the promotion of environmentally friendly production and consumption of energy, have partly supported investment costs for the hybrid installation.

Due for equipment delivery in mid-2021, the self-discharging vessels will be fitted with electrically powered (battery pack) excavators for loading and unloading, which Wärtsilä says will save fuel and be emission free.

The self-discharging bulk carriers being built for Aasen Shipping will be the first of their kind to operate with hybrid propulsion

Alternative fuels

SDC launches methanol fuelled MPP

Hamburg-based design consultancy SDC Ship Design & Consult Gmbh and Breman-based ship operator Liberty Group have announced collaborative plans for the first multipurpose (MPP) vessel design that is ready for both traditional MGO and methanol.

The 5,300dwt MPP vessel is NAABSA certified, will be 84.70m in length and is designed to operate up to a speed of 12knots. It will be equipped with an efficient propulsion system capable of consuming 4.5tonnes per day. Aside from this potentially carbon neutral system, other features include an increased manoeuvrability and optimised view from the ship's wheelhouse.

When the vessel runs purely on MGO (compliant with sulphur cap regulations), it has a total operational range of 5,000nm. But when bunkering methanol, the vessel's range drops to 4,000nm as a result of the fuel's lower energy density per volume. The companies say that although the vessel operates less efficiently with methanol than MGO, it still surpasses the volume efficiency of a comparable LNG-driven design.

SDC and Liberty Group are considering both IMO's sulphur cap and 2050 GHG emission goals, to create a design which is ready for future challenges that may be put in place, such as stricter EEDI requirements. The companies also cite operational, environmental and financial factors as the main contributors for their decision to utilise methanol over other alternative fuels, such as LNG.

Container ships

BV upgrades boxship fire notations

Bureau Veritas (BV) has published additional class notations detailing measures aimed at managing container ship fires.

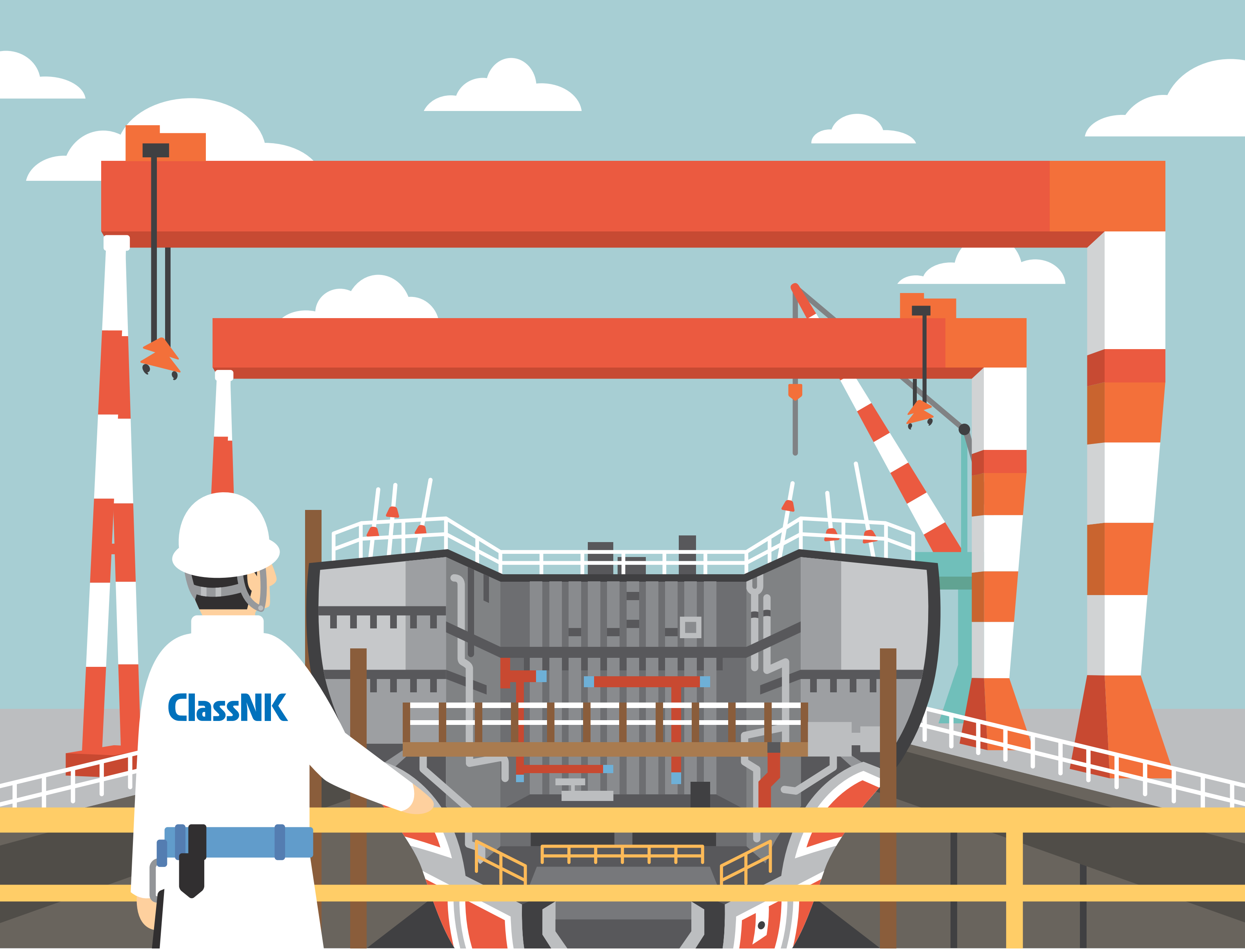
The 'Enhanced cargo fire protection for container ships' (ECFP), which entered into force from 1 January 2020, comes in response to an alarming number of fire incidents on board very large container ships in recent years.

In developing the new standards, BV initiated a cross-industry working group consisting of container ship operators CMA CGM and COSCO Shipping, shipyards/designers CSSC and MARIC, the Marseille Naval Fire Battalion, salvagers Smit and TMC Marine, as well as the French and Italian maritime authorities. The group used the HAZID approach to scrutinise every step of a fire incident before developing what BV calls risk control measures (RCMs).

Gijsbert de Jong, BV's marine marketing and sales director, explains: "We started with fire prevention and ignition sources, looking at detection, manual and fixed firefighting, and containment and protection of the cargo. We also thought about what you should do if everything fails. How do you make sure people can still evacuate?

"We ranked the RCMs in terms of their technical effectiveness, ease of implementation and cost considerations. The best scoring RCMs were then put forward for the enhanced regulations."

These RCMs include: improved firefighting capabilities on deck, centralised ventilation control for cargo holds to minimise the air that can reach the holds in a fire incident, improved firefighting and fire contain-



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ment in the holds (using water spraying and intentional flooding), better protection of the accommodation block and LSAs, and improved fire detection using still-maturing technologies such as thermal imaging and infra-red.

The new notations have three levels. The first, ECFP-1, covers portable equipment and arrangement that can be easily retrofitted. ECFP-2 includes additional arrangements such as a fire detection system, water supply and flooding system. The highest standard, ECFP-3, will also cover the incorporation of innovative technologies to goal-based standards.

BV says assessment of these technologies will form the basis of further consulation involving IMO, IACS, marine insurers and flag states.

Lubricants

White paper warns of low-sulphur engine risks

Lubrizol, a global supplier of additives for industrial lubricants, gasoline and diesel fuel, has warned that legacy cylinder oils may not protect ship engines from the side-effects of using very low sulphur fuel oil (VLSFO).

Research outlined in a new white paper published by the US-based chemicals company advocates that shipowners use specifically formulated lubricants when operating with VLSFO. Lubrizol's marine bench and engine tests revealed a high degree of variability in deposit formation and combustion characteristics among VLSFO blends, even when the samples were taken from a relatively small geographical area.

Lubrizol's findings appear to be supported by early reports of high sediment levels in low-sulphur fuels. In test samples of 0.5% sulphur fuel taken in Houston and Singapore, sediment levels exceeded the specifications in the ISO 8217:2017 marine fuel standard. Such sediments can cause damage to ship engines by accumulating as sludge in fuel storage, handling and treatment systems.

Moreover, marine cylinder oils have not previously had to handle low-sulphur fuels with this degree of deposit formation, and their additives may not be robust enough to cope with variable VLSFO characteristics.

There has been widespread uptake of VLSFO blends since the introduction of IMO's sulphur cap on 1 January. Lubrizol's white paper warns that if the lubricants chosen by ship operators are not robust enough to maintain engine cleanliness, it could lead to an increased incidence of engine deposits and costly damage.

Ian Bown, Lubrizol's technical manager for marine diesel engine oils, says: "Shipping faces an unprecedented fuel switch in 2020. The majority of ship owners and operators that are planning to comply with VLSFO should understand that legacy lubricant products used with low-sulphur fuels will not necessarily protect their engines as required."

The report concludes it is likely that the use of additive chemistries will continue as shipping's fuel market evolves and diversifies in the pursuit of IMO's GHG targets.

Class societies

IRClass reports fleet growth in 2019

The Indian Register of Shipping (IRClass) has revealed that its classed fleet grew by 3%, including a 16% rise in the foreign-flagged vessels, over the past year.

By the end of 2019, IRClass was recognised by 45 flag states worldwide and received several flag authorisations, including Cyprus and Denmark. As the Middle East is its strongest market outside of India, the society also opened an office in Qatar, with a view to capitalising on oil and gas opportunities. Elsewhere in the world, IRClass opened another European office in the Netherlands.

IRClass's consultation and classification services have been called upon for a wide range of new construction projects for small and medium-sized vessels, including cement carriers, mini bulk carriers, passenger ships and offshore support ships. It continues to develop a particular niche for inland vessels, and has been engaged in projects in countries such as China, Korea, Japan and Malaysia.

Looking ahead, IRClass says it will concentrate on enhancing its classed fleet and improving its service offerings during 2020. Is is also keen to continuing its its global visibility through attendance of key industry events such as Asia Pacific Maritime, Posidonia and SMM and establish a presence in Africa and South America.

The class society's executive chair, Arun Sharma, is the current Chair of IACS and will complete his one-year tenure in June 2020. *NA*

Arun Sharma, executive chair at IRClass, chair of IACS

Triumph, catastrophe or something more mundane?

Malcolm Latarche reflects on the global aftermath, or lack thereof, following the sulphur cap's introduction on 1 January 2020

For many months now, the hot topic in shipping has been the 2020 sulphur cap and its many potential impacts. The deadline day has now been passed and while it may be too soon yet to determine if it has been a triumph, a catastrophe or something more mundane, there have been some developments that are of interest.

Thankfully, there has been no report yet of a major incident caused in some way by any of the compliant fuels that have been replacing conventional HFO. That could be because it is just too early for compatibility issues to have been encountered. Ships generally bunker with sufficient fuel for quite lengthy voyages and so only a relatively small number of ships would have yet bunkered more than once since the 1 January. Many would have bunkered with compliant fuels long before that date so the issue of problems arising when fuels are mixed may soon take place.

On the general quality of the new VLSFO there have been some concerns. Fuel testing and management specialist Veritas Petroleum Service reports that between 24 December 2019 and 21 January, it issued seven Bunker Alerts relating to sediment issues within VLSFO fuels. These Bunker alerts show that sediment problems within VLSFOs is not restricted to a single port, or region, over this recent four week period, as alerts have been issued in relation to fuel supplied in Singapore, Piraeus, Amsterdam, Rotterdam, Miami and San Vincente.

The frequency of alerts caused Steve Bee, Group Commercial & Business Director of VPS to say the he had never known of such a concentrated frequency of bunker alerts to be issued in relation to a single fuel quality problem.

The inclusion of Singapore and Rotterdam – two of the world's largest bunkering hubs – might be seen as a little disconcerting, since it had been assumed that the biggest problems would be in smaller ports where low levels of turnover of bunkers and laxer quality standards would combine to degrade quality.

There has been little information yet about shortages of compliant fuel, although the Standard P&I Club did report in mid-January that Chinese authorities had acted in two cases where ships were found to be burning non-compliant fuel. In a PSC inspection in Qingdao, a ship was found to have fuel with a sulphur content of 0.67777%mm. The second case involved a ship in Xiamen which was found to be non-compliant after loading compliant fuel. It is assumed that the fresh fuel was contaminated by residues in the fuel system. It is not clear if either ship was penalised.

On 20 January, a joint statement by the Paris and Tokyo MoUs on port state control effectively put shipowners on alert that the ban on carrying non-compliant fuels, which comes into effect on 1 March, would be strictly enforced. The two PSC authorities justified this by saying they have been advising ships for a year of the impending rule and had judged that crews were sufficiently aware so no leniency would be justified.

Tensions between the US and Iran in January resulted in a spike in the price of crude oil and a subsequent jump in bunker prices. That tension seems to have eased and crude prices have dropped significantly in the third week of January. Even so, as of 20 January it was noticeable that the prices for VLSFO and MGO were roughly on the same level and showing a premium of between US$200 and US$300 per tonne over IFO380.

That level of difference was sure to put a smile on the face of those owners who have opted for scrubber installations as their strategy to meet the 2020 sulphur rules and probably also for time charterers, who are paying much higher daily rates for scrubber equipped vessels.

Although not directly linked to the 2020 sulphur cap deadline, January also saw public comment on a discussion paper presented by Germany and Finland for the IMO's PPR 7 Sub-committee meeting to be held in February. The paper (PPR 7/8) is actually linked to an agenda item where black carbon emissions impact on the Arctic is to be considered but it must surely have wider implications.

In tests funded by the German Environment Agency and involving MAN Energy Solutions and DNV GL, it was found that 2020 compliant VLSFO fuels containing high levels of aromatics, produce far more black carbon than conventional HFO. Distillates and a synthetic gas-to-liquid fuel both performed better than the VLSFO and HFO fuels tested.

Scrubbers of course have the added advantage of reducing black carbon and particulate matter, as well as SOx emissions, so the test result presented to PPR 7 will give added weight for advocates of their use. However, scrubbers did suffer some minor setbacks, with Pakistan and Bahrain both issuing notices banning washwater discharge from open-loop scrubber systems in port waters. NA

LNG

GTT celebrates order influx

GTT have secured a series of orders for their specialised LNG containment systems, predominantly from South Korean shipyards.

By late December 2019, the French engineering company had received orders to equip eight new LNG carriers with their Mark III Flex membrane container system. The vessels, each with capacity of 174,000m^3, were all placed by Hyundai Samho Heavy Industries (HSHI) and Hyundai Heavy Industries (HHI) and will be split equally across the two. HHI is building the vessels for undisclosed European and Asian ship-owners, building two vessels for each client respectively. HSHI are to build four vessels solely on behalf of another European ship-owner.

Philippe Berterottiere, GTT's chairman and CEO, says: "These eight last orders confirm the dynamism of the market observed throughout this year. This brings the number of LNGC orders obtained in 2019 to 57, which is a record year for GTT and illustrates the partnership of excellence that we have with the shipyards of the Hyundai Group."

In mid-December, GTT announced an additional order for its Mark III system onboard another 174,000m^3 LNG carrier, also being built by HSHI.

Meanwhile, South Korean shipyard Daewoo Shipbuilding & Marine Engineering (DSME) have also ordered the tank design of a new 174,000m^3 LNG Carrier from GTT, placed on behalf of an undisclosed European shipowner. With DSME due to deliver the ship in early 2022, it will feature another of GTT's specialised membrane containment systems, the NO96 GW.

After a difficult few years, there are signs that South Korean shipyards are enjoying an upswing of fortunes, particularly with regard to LNG carriers, where they face growing competition from China's Hudong-Zhonghua shipyard. GTT also announced in December that it is supplying its NO96 L03+ membrane containment system for two 174,000m^3 capacity vessels.

Ballast water treatment systems

Bio-UV and Hai Cheung enter partnership

Leading French ballast water treatment manufacturer Bio-UV Group has entered a partnership with Hong Kong-based maritime equipment supplier, Hai Cheung Trading (HCT), which will support the sale and promotion of Bio-UV's ballast water treatment system (BWMS), Bio-Sea, in Asia.

As part of the partnership, HCT will support the supply, installation and commissioning of the Bio-Sea technology at Chinese shipyards. In addition, Bio-UV will transfer the Chinese assembly and production of its Bio-Sea parts to HCT's Nanjing site, as the French company aims to appeal to a growing market by increasing its production flexibility and responsiveness.

Xavier Deval, business director for Bio-Sea, comments: "This partnership comes at a time when the market is very favourable towards UV-based BWMS. The alliance we have formed with HCT aims to raise the competitiveness of our technology in the market."

UV-based products, such as Bio-Sea, are growing in popularity as they are chemical free and unaffected by variable factors, including salinity or temperature. Bio-Sea's UV disinfection process takes place during the ballasting and deballasting phases using high intensity lamps that emit UV-C rays, ensuring that microorganisms are destroyed entirely.

The system has received type approval certification from both IMO and US Coastguard (USCG), which Deval emphasises will appeal to Asia shipowners looking to comply with the relevant requirements. "This, combined with Bio-Uv's high-performance systems and HCT's enhanced knowledge of China's maritime ecosystem, will ensure we are in pole position to quickly and effectively meet the Asian shipowners and shipyards' requirements," he adds.

Radar

Furuno launches magnetron-free radar

Japanese electronics company Furuno has developed a solid-state radar, which is now available in both X-band and S-band frequencies.

Furuno has added a new X-band model to its FAR-2xx8/8xx0 NXT series. In a first for the

Furuno FAR 3000's multifunction display (MFD) capability

company, the 800W IMO Commercial/Chart Radar will provide both X-band and S-band. The equipment will be available from summer 2020.

The company's new technology is compliant with IMO performance standards and the European Union's Marine Equipment Directive (MED) approval is planned for March 2020. The radar is targeted towards all IMO Category 2 and Category 3 vessels, which includes ships with a gross tonnage ≤500.

A significant feature of Furuno's solid-state radar technology is the removal of its consumable part, the magnetron. Solid-state technology replaces the magnetron with electronic components to generate microwaves. As such, the solid-state radar requires no pre-heating time and can begin operating much faster than its magnetron counterpart.

Although the price of magnetron radars remains comparably cheaper, Furuno claims that removing it will ensure less power consumption without compromising its high-performance level. Moreover, the technology will not wear down and does not require maintenance work, reducing the cost of operation.

LNG

Wärtsilä equips next-gen cargo vessels

Finnish technology giant Wärtsilä are to provide LNG propulsion and customised storage systems for four new short-sea cargo vessels.

The next-generation ships, which are being built at the Wuhu Shipyard in China, will be among the first of their kind to be powered by LNG fuel. Each 5,800 DWL lift-on, lift-off (lo-lo) vessel will be fitted with a Wärtsilä designed 34DF dual-fuel main engine, gearbox, LNGPac system and controlled pitch propeller with HP nozzle.

Wärtsilä has collaborated with the naval architect and shipowners to develop specialised solutions for the size restrictions on short-sea cargo ships, which allows its LNGPac storage and supply system to be installed below deck without reducing the cargo hold space. In addition, the company's OPTI Design will tailor its propeller and HP nozzle technology to accurately align with the vessel's hull, thus optimising each ship's propulsion efficiency. The remote monitoring and iCloud-based services used in Wärtsilä's Data Collection Unit (WDCU) optimise operability, fuel economy and periodic maintenance, and will support each of these integrated technologies.

Wärtsilä is due to deliver its equipment during Q4 2020 and the first ship is to be delivered during Autumn 2021. Once operational, the vessels will be Finnish/Swedish Ice Class 1A classified and will travel in the Baltic and North Seas.

Aside from these four short-sea cargo vessels, Wijnne & Barends have six additional ships that it previously ordered, which will also be fitted with Wärtsilä main engines and controlled pitch propellers.

Scrubbers

Rivertrace washwater monitor gets approval

British-based technology developer Rivertrace announced that its Exhaust Scrubber Washwater Monitor, SMART ESM, has received a statement of compliance (SoC) from DNV GL.

Washwater used by wet scrubber systems to remove pollutants from exhaust gas must be monitored to ensure it meets IMO regulations for water quality parameters prior to discharge in the ocean.

Rivertrace's SMART ESM is a washwater monitor that both measures and records the regulated water quality parameters' polycyclic aromatic hydrocarbons (PAH), turbidity, temperature and pH. The monitor can be used on open-loop, closed-loop and hybrid scrubber systems, and is already onboard vessels. The system also supports continuous compliance with IMO washwater discharge limits, as it allows ship operators to monitor washwater in real time at both inlet and outlet.

The SoC outlined by DNV GL confirms that Rivertrace's SMART ESM system operates with an acceptable accuracy for the measurement of the above parameters, within the ranges required by MEPC 259(68). The company says that this certification assures its customers that its SMART ESM technology is fit for purpose. *NA*

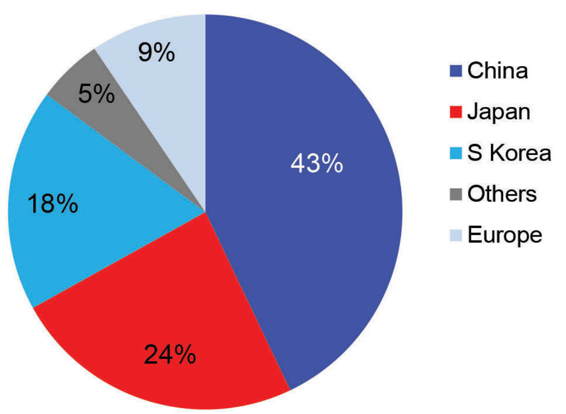
Rivertrace's SMART ESM system has been approved by DNV GL

Clarksons Research: Historical and Scheduled Deliveries Report

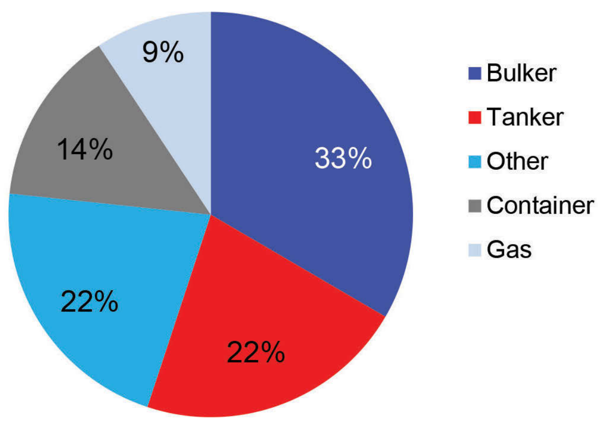
Data extract from World Fleet Register available at www.clarksons.net/wfr

Vessel Type	2008		2009		2010		2011		2012		2013		2014	
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half
VLCC >= 200,000	18	23	33	20	30	24	35	27	27	22	21	9	14	10
Suezmax 125-200,000	8	5	22	22	26	11	26	18	30	15	23	4	4	4
Aframax 85-125,000	26	42	63	33	39	31	28	31	30	15	14	6	4	13
Panamax Tankers 55-85,000	17	26	26	12	15	16	19	10	9	6	7	5	3	1
Products 25-55,000	73	92	92	67	65	46	45	27	27	30	49	29	49	49
Products 10-25,000	8	5	6	5	7	7	8	6	13	6	9	4	1	8
Chem & Spec. 10-55,000	83	103	106	69	77	59	53	41	39	8	8	13	12	11
Tankers < 10,000	61	93	71	70	65	53	53	51	70	35	35	28	25	22
Capesize > 100,000	21	24	33	77	101	111	129	122	149	65	63	40	56	38
Panamax 80-100,000	15	17	27	21	60	61	81	97	140	94	101	68	62	35
Panamax 65-80,000	23	20	18	15	18	33	36	44	53	39	34	42	42	20
Handymax 40-65,000	66	61	84	100	168	166	199	198	228	146	147	119	98	102
Handysize 10-40,000	98	109	177	195	186	186	186	179	226	117	116	83	96	67
Combos > 10,000	0	0	0	0	3	2	3	0	0	0	0	0	0	0
LNG Carriers	25	26	22	17	15	12	5	10	1	2	4	13	14	19
LPG Carriers	27	33	25	18	18	18	16	14	13	8	22	16	14	14
Containers > 8,000 teu	25	26	21	14	29	33	48	30	51	28	51	33	59	42
Containers 3-8,000 teu	69	62	59	59	76	41	31	21	39	19	46	29	26	25
Containers < 3,000 teu	138	109	69	55	57	26	33	34	37	40	29	19	22	27
Offshore	15	17	11	19	21	24	27	22	30	10	11	19	32	30
Cruise Vessels	6	3	3	6	9	4	4	2	6	1	6	0	3	2
Passenger Ferries	21	7	11	7	10	13	11	10	11	8	6	6	12	8
Other	156	158	152	161	174	180	183	183	190	99	99	80	71	62
TOTAL	**999**	**1,061**	**1,131**	**1,062**	**1,269**	**1,157**	**1,259**	**1,177**	**1,419**	**813**	**901**	**665**	**720**	**609**

Orderbook by builder region (number of vessels)



Orderbook by sector (number of vessels)



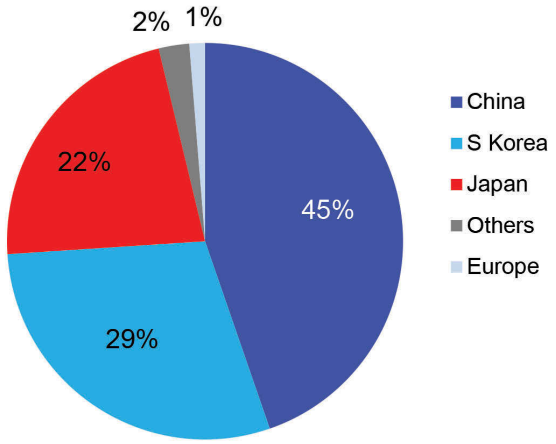
2015		2016		2017		2018		2019		Scheduled Orderbook		
1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	2020	2021	2022
9	11	23	24	29	21	21	18	39	29	42	26	3
7	3	8	19	35	22	25	7	23	3	34	21	7
22	10	31	22	36	28	26	24	41	12	25	48	10
2	1	7	13	10	11	7	6	6	7	16	7	1
60	57	60	42	39	25	27	22	49	45	87	38	5
4	0	3	2	6	6	8	6	4	3	17	8	0
36	29	43	36	38	31	45	41	35	28	71	10	8
12	14	25	16	24	28	42	37	20	23	52	20	0
46	42	65	39	55	20	30	21	31	48	127	64	13
57	41	71	40	75	27	39	25	69	64	170	73	12
19	4	1	2	6	1	2	2	1	0	7	0	0
144	121	124	94	124	54	58	33	55	76	158	66	10
100	83	85	45	68	31	47	42	47	36	105	43	4
0	0	0	0	0	0	0	0	1	2	3	2	0
16	16	15	18	20	12	32	23	22	20	48	64	31
25	40	49	33	45	17	26	9	16	16	55	30	9
58	62	37	26	34	36	47	23	27	23	46	54	20
18	6	2	0	2	5	7	3	6	1	9	2	0
27	35	39	27	35	42	50	38	43	50	171	54	4
25	14	25	20	18	24	25	13	9	9	49	24	10
5	1	8	2	7	3	8	4	12	10	24	26	25
13	8	6	15	20	10	11	18	15	15	47	39	14
71	48	50	60	50	54	49	46	55	49	171	66	10
776	**646**	**775**	**595**	**776**	**508**	**632**	**461**	**626**	**569**	**1,534**	**785**	**196**

Data includes all vessels with LOA estimated at >100m

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

All data taken as of 1st January 2020

Orderbook (DWT) by builder region



Source:
Clarksons Research

把脉经济金融走势 权威解读行业政策
船舶经济贸易
SHIP ECONOMY & TRADE

China fully prepared for sulphur cap

In compliance with IMO's sulphur cap and the country's ongoing environmental protection efforts, China has outlined clear the regulatory requirements for low sulphur usage in its waters

Recently, the China Maritime Safety Administration issued its 'Implementation Scheme of 2020 Global Marine Fuel Oil Suphur Cap', announcing that China will formally implement IMO's sulphur cap on 1 January 2020 and make arrangements for relevant specific matters. It is clear that China is well prepared after nearly four years of putting a system of emission control areas (ECAs) into practice, as well as establishing a basic supply system for low sulphur fuel.

According to China's sulphur cap implementation plan, from 1 January 2020, international ships entering waters under Chinese jurisdiction are not permitted to use fuel with a sulphur content surpassing 0.50%m/m. Moreover, international ships entering China's domestic river ECAs will not be permitted to use fuel surpassing 0.10%. As of 1 January 2022, international ships entering China's Hainan ECA will also abide by the 0.10% restriction. From 1 March 2020, international vessels travelling in waters under Chinese jurisdiction will not be permitted to load fuel with a sulphur content higher than 0.5%. Furthermore, beginning 1 January 2020, vessels will not be allowed to discharge open-loop scrubber washwater in China's ECAs.

Industry experts claim that work related to green shipping has been pushed hard in China. The country's active response to IMO's 2020 sulphur cap is not only the result of China's compliance with international laws and regulations, but also reflects its need to promote environmental protection.

At the beginning of 2015, China introduced the implementation plan for ECAs in the Pearl River Delta, Yangtze River Delta, and Bohai Sea (Beijing-Tianjin-Hebei). On 1 January 2016, the emission control areas were officially implemented in these three zones. Since then, with the introduction of more stringent ECA systems and next-stage emission reduction control standards in Shanghai, Shenzhen and other regions, China's requirements for emissions control have become much stricter. In some zones, the required sulphur content of fuel has been reduced from 0.5% to 0.1% and at the same time, the scope of these ECAs is also expanding.

CSSC Chengzi expects to install desulphurisation units on more than 80 vessels

Industry experts point out that the country faced great pressure when it introduced the 2015 ECAs. At that time, many people in the industry questioned whether it was necessary for China to become the first developing country to set up ECAs. However, it now seems that the establishment of ECAs has not only had a positive effect on the environment, but also has not caused any serious problems affecting peoples' livelihoods.

Fully prepared

Since most ships choose to use low sulphur fuel oil (LSFO) in order to meet the sulphur requirements, China, at an early stage, took measures to ensure its coordinated supply. In 2017, China released and issued a series of policies, one of which promoted the establishment of a bunkering infrastrucure for LSFO. Other policies included guiding domestic refining and chemical enterprises to produce compliant fuel, promoting its benefits, and allowing oil supply enterprises to operate across regions. Further policies involved expediting the development and revision of the fuel standards, completing research and revision of relevant standards and specifications for marine gas oil and diesel, and the procedures for their inspection. Prior to the implementation of the sulphur cap, China was also working hard to establish a national unified ship fuel reporting information system.

China's large oil companies were already producing and supplying LSFO well in advance of IMO's deadline. It was reported last year that CNPC, Sinopec, CNOOC and Sinochem Group planned increase the production capacity to 18.15 million tonnes per annum by 2020.

Some pilot free trade zones also launched 2020 action plans for LSFO. For example, Zhejiang's pilot free trade zone is reliant on the existing and ongoing petrochemical industry base in Zhoushan to produce stable and reliable LSFO that has a price advantage over competitors, and to build a LSFO bunkering facility for northeast Asia.

Ship operators are the companies that will be most heavily affected by the sulphur cap and industry insiders warn that in choosing their fuel they should purchase from regular suppliers, provide their crew with necessary training, and evaluate whether or not modifications to their fuel systems and tank cleaning process are required. "With the advanced arrangements of the country and the concentrated efforts of all parties, work in response to the sulphur cap will be well organised. This will not only promote effective compliance in China, but also further promote the progress of China's environmental protection cause," says an industry insider. *NA*

China enhances its strengths while the maritime market waits for recovery

Mega-mergers, strong alliances and a narrowing competitive gap between global shipbuilding powerhouses mean that when market recovery commences, China is aiming for a greater share. Jane Chen, MacGregor's vice president for strategy and head of China, explains

The global shipping and shipbuilding markets are waiting for recovery, and at the forefront of this hungry queue is China. When this comes, it will be met by leaner, more efficient and technologically advanced players than the industry has ever known.

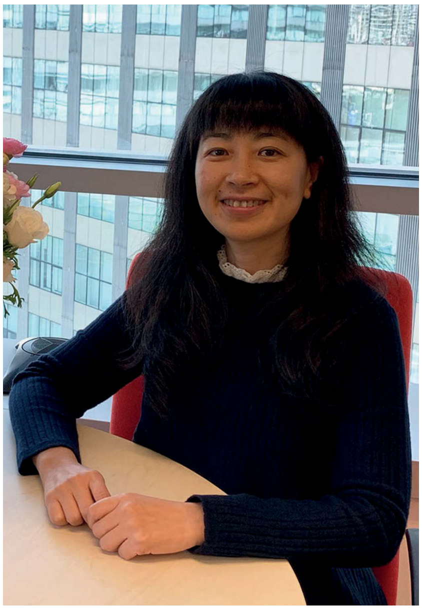
Gaps between the global shipbuilding giants are narrowing, and capabilities that once distinguished a country's expertise in building particular vessel types are gradually diminishing. Within this levelling market, China is poised and ready to compete in both its traditional grounds and within previously untapped arenas.

It is not possible to consider China's maritime position without taking into account the whole market and its potential for growth. Intelligence specialist, Clarksons Research, has downgraded its 2019 forecast for global seaborne trade growth from 2.9% to 1.7%, representing the slowest annual growth rate since 2009. However, it still predicts a recovery commencing in 2020 with more meaningful growth forecast during 2021 and 2022.

The recovery of the offshore oil and gas market is expected to take a few more years. Currently, the price per barrel of oil has stabilised at around US$60, which has been widely accepted as a viable level for offshore field development. This is possible because the industry has become more cost-competitive than before, and adopted new solutions and technology advances that have realised efficiency benefits. However, oversupply in the market means that there are still many vessels waiting to be re-activated before the need to build new ones materially increases.

Barriers to growth

Global economic uncertainty still grips the maritime industry; a difficult situation exacerbated by protectionism, trade tensions and sanctions.



Jane Chen, vice president, marketing, business development and strategy, head of China

As the growth of advanced economies has been slowing down, growth in emerging economies has not been sufficient to close the gap, adding to current difficulties. Furthermore, service growth, which should be visible in a market where owners are keeping vessels for longer, is also slow and indicative of cash-strapped companies undertaking only essential maintenance.

An additional impact is the need to comply with environmental regulations, particularly the lower limits on sulphur emissions, and associated costs. Global shipbuilding recovery in both the merchant and offshore markets is driven most strongly by the scrapping of older fleets, with the greatest driver being environmental and regulatory legislation.

While environmental regulations place short-term capital and operating expenditure pressure on the industry and its participants, it will bring us all a much better world in the longer term.

Global shipbuilding stakes

China's position in the global shipbuilding industry is substantial. In terms of contracting activity, Clarksons' analysis at the end of August showed that China held a 44% share of global shipbuilding by number of newbuild contracts placed and a 38% share by tonnage.

However, China currently only secures around 33% of the market by value which is similar to the European shipbuilding industry that builds around 10% of the global fleet by tonnage.

This indicates that while China has diversified from building smaller, simpler vessels to larger and more value adding ships, it is still not comparable with the European yards focused on high-value, high-technology vessels and cruise ships.

China shipyards are well aware of this; it has been a long learning curve but the gaps are narrowing. Although this has been driven in part by the 'Made in China 2025' initiative, strategies were already in place to close the value gap. Chinese state-owned shipyards are now targeting higher-value ship types, including LNG carriers and cruise ships.

In preparation for growth and consistent with the industry consolidation trend, there are mega-mergers taking place within China's shipbuilding industry, primarily between the two state-owned enterprises (SOEs), China Shipbuilding Industry Company (CSIC) and China State Shipbuilding Corporation (CSSC). Post-merger, the combined group will be the largest shipbuilder in the world.

Increasing shipowning position

China also has a growing shipowning role in the industry. For a long time, it ranked fourth in this sector but in 2018 became the second largest shipowning nation, overtaking Japan.

Greece remains the world's largest shipowner, but many new investments have been backed up by Chinese financing and China also became the leader in the second-hand tonnage market during this year.

Central state-owned China COSCO Shipping, including newly acquired OOCL, is now the largest global shipowner with a relatively young and modern fleet, and is also expanding its footprint in international ports through significant investments.

Becoming self-sufficient

All Chinese companies, and particularly the SOEs, are being encouraged to be more independent in technology development and self-sufficient. This is designed to safeguard the country's long-term growth, the integrity of critical industries and to push China to move up the value chain with more speed.

China's SOEs are also major employers, stabilising local communities, and their survival and increasing competitiveness is therefore essential. A strategy that ensures this is one of vertical integration, where a company controls more than one aspect of the supply chain.

While the market is depressed, it is natural for the Chinese SOEs to prioritise 'feeding the family first'. Hence being regarded as a 'family' member for Western players would be beneficial, either through a strategic cooperation or joint ventures.

MacGregor in China

MacGregor has held a strong market position in China for decades, which has been further strengthened through the recent acquisition of TTS.

TTS has three joint ventures in China, two with CSSC and one with CSIC, which are well established and recognised by the Chinese customers. In accordance with Chinese competition authority conditions related to the acquisition approval and for a hold-separate period, MacGregor and the TTS joint ventures must operate independently in the China market. This applies to certain equipment supplied for newbuild projects, with the requirement continuing through to July 2021.

The combination of MacGregor and TTS capabilities globally provides a stronger service network, a wider product range and greater expertise to offer optimised solutions that create even more value for customers, both shipbuilders and shipowners. With a strong parent company and shareholder support, we also have the financial capacity to invest and innovate for our customers; something that not everyone can afford in this climate.

MacGregor also needs to compete effectively in the Chinese market with 'fit for purpose' reliable equipment that is cost-competitive. As such, and for example, we have re-engineered and optimised our portfolio of selected equipment to ensure that it meets the needs of customers with both technologically advanced and more simpler requirements.

Ready for tomorrow

As an industry leader, we must move forward. MacGregor is doing this through the development of innovative, digital technology-enabled and environmentally sustainable solutions that deliver real commercial and operational benefits to customers, and fulfil our social responsibilities.

One notable example is OnWatch Scout, a cloud-based digital solution designed to maximise operational availability and minimise unplanned downtime through continuous monitoring of installed equipment performance. A number of OnWatch Scout pilot trials are currently ongoing, including with Chinese shipowners.

While we are operating in an era of considerable change, MacGregor has extensive local experience. We are able to compete strongly in the market through leveraging an asset-light business model and striving to ensure that our products, systems and services fully meet the needs of our shipbuilding and shipowning customers.

Strategic alliances and joint ventures with Chinese state-owned key stakeholders further strengthen our relationships and market foothold, and help to build a stronger platform to support future growth in China. *NA*

About the author

Jane Chen is MacGregor's vice president, strategy, and head of China, and a member of the executive management team. She joined the company in 1997 from the state-owned enterprise, China COSCO Shipping Corporation Ltd.

Expedition cruising puts seakeeping in spotlight

Kari Reinikainen investigates the seakeeping demands that expedition cruise ships face in rough conditions at sea

Many years ago, a senior technical officer of Carnival group, the world's largest cruise shipping company, said in a presentation that naval architects often do not have experience of harsh conditions at sea. As a result, designers often underestimate the forces that a cruise ship has to face. The rapid development of expedition cruising has put this issue firmly back on the table.

There are about 30 expedition cruise ships on order at the moment. They range in size from roughly 7,000 to 30,000gt. In addition, ships aiming for the top end of the market tend to be much smaller than the 150,000gt plus contemporary market giants.

Ships of this type currently on order have a gross tonnage of about 50,000, while some ultra-luxury cruise yachts have a tonnage roughly half of this. A key difference between these ships and vessels of the expedition type is that they do not sail to regions with frequently challenging sea conditions, such as high latitudes north and south.

On the other hand, several mainstream cruise lines offer voyages that sail in tough conditions. For example, a journey between Buenos Aires and Valparaiso in the austral summer season takes ships via the Straits of Magellan, which often has difficult conditions. Some of these ships have a gross tonnage in the region of 100,000: big ships do not only cruise in the usually benign waters of the Caribbean or the Mediterranean.

Optimal solution compromise of many factors

Finding an optimal solution between seakeeping qualities and other relevant matters usually requires a compromise between various aspects of the ship's design, says Esa Jokioinen, sales and marketing director at Deltamarin, the Finnish consultant naval architects.

"This is a very relevant question when it comes to expedition cruise ships.

Esa Jokioinen, sales and marketing director at Deltamarin

Markus Aarnio, one of the founders of the Finnish naval architect firm Foreship

There are restrictions for the number of passengers ships can take to some regions, like the Antarctica, which limits the size of expedition cruise ships. By the very nature of this business, these vessels often cruise in regions where the sea conditions can be demanding," he tells *The Naval Architect*.

"The smaller size of these ships compels both the designers and operators to pay more attention to seakeeping – it is a bigger question in this segment than in the mainstream cruise industry," he continues.

Deciding on an optimal solution for the design of the ship requires that technical, commercial and aesthetic considerations need to be discussed. "You also need to find out what the architect in charge of the ship's exterior thinks of what is on the drawing board, which can complicate matters," Jokioinen points out.

However, focusing solely on the technical and commercial aspects of the design at the expense of the aesthetics is not advisable, as aesthetics are part of the commercial and functional aspects of the ship. "this is actually a complicated optimisation process," he states.

Inspiration from offshore services industry

The expedition cruise industry has followed the lead of the offshore services industry, which has pioneered the use of various wave piercing designs that several shipbuilders have introduced over the years.

These terms generally offer superior qualities over a traditional bow design. But the seakeeping qualities of the ship is a broader question that also includes other factors e.g. the hull form.

To smoothen the design process, Jokioinen says that technical, commercial and aesthetic aspects of the proposed design should be considered together as early as possible. "Degrees of freedom in modifying the shape of the vessel are smaller the later these aspects are considered in the design project," he adds.

The recent developments in analysis methods allow the designer to have a very comprehensive approach, which takes into account the seakeeping qualities of the vessel as well as added resistance in real operation conditions. For this purpose, Deltamarin has developed a new method called DeltaSeas, which bases these analyses on the actual weather data from the intended operation area.

One of the wave piercing designs that has been introduced in the cruise ship sphere and put almost immediately to test is the X-Bow, designed by the Ulstein Group in Norway and initially used in offshore service vessels.

However, *Greg Mortimer* was completed last year and is the first in a series of 7,400gt vessels for SunStone Ships, the Miami-based tonnage provider, which are designed by Ulstein and feature the X-Bow. The ship was completed by the China Merchants Heavy Industry shipyard in China and soon after delivery ran into heavy seas.

Niels-Erik Lund, CEO of SunStone, says he spent a week onboard and experienced those conditions. "The biggest noticeable difference between *Greg Mortimer* and our second-hand fleet is the complete lack of slamming, vibration and noise from the ocean," he tells *The Naval Architect*.

"On the way from Antarctica to Ushuaia, we had 9m waves, and we continued with a speed of 13 to 14knots. This we would not have been able to do with our other vessels," Lund continues.

"On the positioning voyage (of *Greg Mortimer*) from Cape Town to Ushuaia, I have been told that they had 12m waves and were still doing more than 13knots. On the consumption side, our experience so far is a fuel saving of 50 to 70% compared to our existing fleet," he concludes. *Greg Mortimer* and its sister ships are also significant as they are the first cruise ships built in China for a customer in the West.

Greg Mortimer sets off to boldly go where its namesake mountaineer has gone before

Beam-draft ratio, bow and stern focal

As the seakeeping qualities of a ship affects many other factors, they usually receive a lot of attention at the beginning of the design process. One of the key aspects that a designer needs to look at is the beam to draft ratio: a figure in the region of four can be regarded as fairly optimal.

However, the larger the ship, the more difficult it is to have a good beam to draft ratio. Usually a draft cannot exceed 9m, which creates a ratio higher than 5 on the largest ships, says Markus Aarnio, one of the founders of the Finnish naval architect firm Foreship. On the other hand, these ships are already so large that seakeeping is not usually an issue.

A fine, raked bow may look good – and many cruise liners in the 1970s in particular were built with one – but an excess results in propensity for slamming. Moreover, it is not just the bow that requires attention, the stern of the vessel can cause slamming as well.

Since the 1980s, most cruise ships have been built with a transom stern and their shape, too, needs to be optimised to reduce slamming while in harbour or in slow speed conditions. "Flat stern is a problem in port, where slamming due to waves can cause problems," Aarnio notes.

Once the design has been completed, model tests will follow. Sensors in the bow measure stress at various speeds and stabilisers are engaged to counter the waves that will come from different directions and at different periods.

This enables the design team to define the seakeeping characteristics for the vessel, which can help the master to decide what speed should be used in the conditions that prevail at a given time. "This is important, for example, to be able to avoid parametric rolling," Aarnio points out.

New damage stability rules require higher GM

Heavy seas can result in bow slamming and force the master to slow the ship down. If the speed needs to be reduced significantly, the stabilisers will no longer work and the ship may start to roll more.

Changes in damage stability rules mean that in general ships need to have higher metacentric height (GM) than before. This can mean less comfort in heavy seas due to higher accelerations, especially for smaller ships.

"In pioneering smaller cruise ships, the metacentric height was in the region of 1.5m. Today the figure has risen to the region of 2.5 to 3.0m," Aarnio points out. The SOLAS 2020 rules that demand a higher metacentric height than the previous ones also mean that accelerations of the ship in adverse sea conditions become more pronounced, which again will make them more uncomfortable, he concludes.

Orders for expedition type ships started to flow in quickly after the contents of the IMO's Polar Code that took effect in the beginning of 2017 became known. Images of these vessels show, generally speaking, fine hull lines more akin to the trans-ocean liners of the 1950s and 1960s than most larger cruise ships of today.

As the mainstream cruise industry grows, the largest ships are first employed in regions where their operators can fill them, usually starting with the Caribbean.

But then a phenomenon well established in container shipping starts to take place: smaller vessels are moved to other regions to make way for the bigger newcomers. This cascading of tonnage means in practice that ships originally intended for the Caribbean will eventually be employed in worldwide trading.

As a result, while such events may not be very frequent, even very large cruise ships can face extreme weather conditions. Video clips shot by passengers on such occasions and posted in the social media would suggest that size of the ship alone offers limited immunity against the fury of the sea. *NA*

Another buoyant year for cruise ships?

2020 sees the entrance of a new operator with Virgin Voyages' inaugural vessel, *Scarlet Lady*, but for most cruise shipowners the emphasis will be on fleet expansion and consolidation

Virgin Voyages' *Scarlet Lady* is scheduled to set sail in March

All sectors of commercial shipping are subject to market fluctuations, but merchant vessel operators can generally feel confident that, for all the ebb and flow of supply and demand, there will still be a need to transport goods. Cruise operators, by contrast, must also accommodate the more volatile whims of popular taste.

It's a problem that has grown acute in recent years with the upsurge in environmental consciousness. At the time many of the cruise ships scheduled for delivery during 2020 were originally ordered, typically three or four years ago, Extinction Rebellion wasn't yet established and Greta Thunberg an anonymous Swedish schoolgirl. Although IMO instruments, particularly the sulphur cap, establish a minimum standard, cruisegoers are increasingly expectant that their journeys are being operated sustainably.

Today's cruise passengers are also an eclectic breed and while the family-friendly, one-size-fits-all model of cruise ships continue to claim a substantial market share, operators have increasingly targeted niche demographics.

That's certainly the case for this year's notable new player, Virgin Voyages, which will commence activities with the launch of its first vessel, *Scarlet Lady*, from Miami in March and has a strict 'adults only' policy. With facilities including a nightclub, fitness centre and even an onboard tattoo parlour, Virgin Voyages says the emphasis is on fun and wellbeing.

Described as "the cruise ship for rock stars" where dancing on the tables is actively encouraged, its short Caribbean itineraries appear to be designed with the Instagram generation in mind.

At 277.2m and capacity for 2,770 passengers (or 'sailors', as Virgin prefers to call them) *Scarlet Lady* is the first in a series of four that will be built for the new operator by Fincantieri at its Genoa and Sestri Ponente yards, up to 2023. Power will come from two eight-cylinder and two 12-cylinder Wärtsilä 46F engines, for a total output of 48,000kW.

A power system supplied by Swedish company Climeon Ocean will convert waste heat from the engines into electricity. Additionally, microwave-assisted pyrolysis technology from Norway's Scanship will be used to convert carbon-based waste (such as food and sewage) into energy.

Wärtsilä will have responsibility for maintenance as part of a 10-year remote monitoring contract and are also providing the vessel's NACOS Platinum integrated navigation solution. It will also supply the hybrid scrubber and selective catalytic reduction (SCR) systems for *Scarlet Lady* and its sisters, as Virgin Voyages says the lack of LNG infrastructure deterred it from choosing gas propulsion.

Excellence and Edge

Conversely, although it has been a strong advocate of open-loop scrubbers through its involvement in the Clean Shipping Alliance 2020, Carnival is increasingly turning to LNG to power its newbuildings. In 2016, anticipating the delivery of the Excellence class series of LNG-fuelled cruise ships that began with 2018's *AIDAnova*, it signed agreements with Shell allowing its ships to refuel from Shell's LNG bunkering vessels.

This year will see the delivery of the third Excellence vessel, *Iona*, for Carnival's P&O Cruises' line. Built by Meyer Werft and due for delivery in May 2020, the 337m, 5,200-passenger capacity *Iona* will be the largest ever built specifically for the British market. A fourth Excellence vessel, Carnival Cruise Line's *Mardi Gras*, is also due for delivery in late 2020.

Consolidation of fleets with sister ships will be a recurrent trend this year. The Royal Caribbean-owned Celebrity Cruises is due to take delivery of *Celebrity Apex*, a sister to 2018's *Celebrity Edge*, from French shipyard Chantiers de l'Atlantique. Arguably, the most eye-catching feature of the Edge class vessel 'The Magic Carpet', a cantilevered movable deck that will rise from Decks 2 to 16 and serve as a bar and restaurant. Assuming the vessel is delivered on schedule in April it will have been impressively completed in just 20 months of the steel cutting date.

Two pairs of eight and 12-cylinder engines Wärtsilä 46F engines provide the power and propulsion, but with the additional support of a Wärtsilä 32E that allows the vessel to continue operating with one main engine down. Efficiency technologies include an air lubrication, parabolic ultra-bow (an evolution of the bulbous bow). Chantiers de l'Atlantique has not yet indicated whether it plans to install the same hydrothermal oxidation waste treatment system that was used on *Celebrity Edge*, which were used in prefrence to conventional incinerators.

The French shipyard is also expected to deliver the *MSC Virtuosa*, a sister to last year's *MSC Grandiosa* in September. With capacity for 6,297 passengers and boasting an 111m indoor promenade, fine art museum and onboard Cirque de Soleil show, it could be among the last MSC vessels to use conventional fuels and scrubbers, as most its future vessels have been announced as LNG fuelled.

Expedition growth

In last February's *The Naval Architect* we billed 2019 as the 'Year of the Expedition' and there will be a further influx of expeditions during 2020, with around 20 scheduled for delivery from the likes of Hurtigruten (*Fridtjof Nansen*), Ponant (*Le Bellot* and *Le Jacques Cartier*), SunStone (*Ocean Victory*), Crystal Cruises (*Endeavor*) and Lindblad Expeditions (*National Geographic Endurance*).

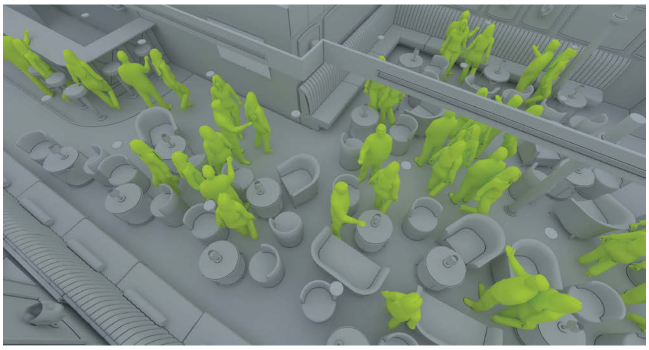
While European yards, in particular those with experience building ice class vessels for the offshore industry, continue to dominate this sector, *Ocean Victory* will be the second of the Ulstein-design Infinity-class vessels to be built by China Merchants Heavy Industry (CMHI), following the much-vaunted *Greg Mortimer* late last year (see *TNA*, January 2020). CMHI is due to deliver a further five Infinity vessels during 2021 and 2022.

For a comparatively new sub-sector there are already more than 30 expedition ships on order worldwide and well over 100 cruise ships overall expected between now and 2027. Yet while there are concerns about both overcapacity, and the 'exclusivity' of the cruise ship experience being undermined, there's no obvious signs of a downturn.

Moreover, most analysts believe there's no immediate prospect of a global recession. Still, as current efforts to contain the coronavirus have provided a timely reminder, an industry built on people's desire to travel should probably be wary of how quickly things can change. *NA*

Is IoT technology connected to the future of cruise design and management?

Matthew Jensen discusses connected cruise – how real time passenger movement and equipment/fixture analysis can improve the operation of a passenger liner



Paramat's IoT tech can monitor passenger movement in real time

With the future market strengths and demand for the cruise market ahead, we now see considerable orders for large-scale newbuild fleets offering unique leisure facilities and luxury environments similar to land-based 5-star hotels.

As we evolve the shipbuilding process with rapid prototyping, Design for Manufacture and Assembly (DFMA) and assistive manufacturing technologies, design tools begin to adopt systems such as Building Information Modelling (BIM, see also p.35-36), VR and computational design (through Artificial Intelligence), resulting in a closer relationship between design and manufacturing supply chains. Within the shipbuilding context, the landscape of future shipyards is likely to change with digital fabrication systems implemented for shell, hull and fit out.

From a design, engineering and facilities management standpoint, we have approached cruise ship revitalisation projects with tools such as BIM, additionally allowing us to explore new digital methods for auditing onboard environments, assets, movement, defects and facilities.

With the innovations currently in force for corporate newbuild shipbuilding and existing refit, parallel changes also occur within the fleet operations and facilities management of a vessel throughout its asset lifetime. At the process of handover, the management of production information and equipment data is contained within owner manuals (OM handbooks), which can quickly become discounted whilst under the supervision of facilities managers, crew members and owners.

Digital platforms such as BIM provide a benchmark to assist with a fully accountable system of architectural, engineering and production information, essentially allowing designers to simulate and visualise safety and capacity planning studies of the ship, as well as onboard asset performance.

After having prolonged experience working with fleet revitalisation projects, it is apparent that, based on the 'pain points' feedback from large cruise fleet operators, major issues continue to occur with regards to capacity flow and passenger movement during full operation, both at sea, embarkation and disembarkation intervals. This partly is a result of the onboard environment changing from its initial inception and function when laid down, and without a major structural re-plan, which causes 'pinch points' within the onboard layout.

Capacity issues

This raises a series of questions – what changes to onboard environments can be made to improve passenger capacity? What allowances have been made to resolve overcapacity within key onboard environments during emergency disembarkation?

After researching customer experience reviews and loyalty reports, it is evident that a common issue throughout the cruise industry relates to the lack of adequate flow and circulation, especially at arrival and departure periods. This issue develops major flaws in the passenger experience and loyalty to operator brands, with long-term customers now opting for smaller vessels with reduced Pax quantities. Operators have introduced various methods regarding process, such as boarding and disembarkation time slots for passengers. However, the issues still arise regarding the lack of appropriate dwell areas for passengers whilst the ship is replenishing supplies and environments for the next turnaround.

Operators also face complexities with managing the logistical requirements for hotel supplies whilst passengers are still occupying guestroom cabins during the disembarkation process, resulting in smaller windows for cleaning, maintenance and refreshing for future occupation. Some operators encourage passengers to temporarily occupy 'revenue areas' such as bars or retail arcades, in order to further increase sales during the ships downtime periods (e.g. at the beginning or end of cruise itinerates). However, no procedures or processes have been formulated, which results in highly disruptive passenger traffic in and around the core public spaces, departure and arrival transitional areas (gangways) of the ship.

With onboard technologies rapidly improving, including passenger assistive systems such as wearable Radio Frequency Identification (RFID) bracelets; allowing passengers to access cabins, purchase amenities, and share preferential information with crew (such as allergies) – the future potential for 'smart connected cruising' has never been greater until today. Following the incorporation of BIM in marine data, real time passenger metrics can be captured in order to simulate crowd movement when master planning the architecture for the next passenger vessel.

By addressing any potential pinch points with passenger flow and capacity, particularly at embarkation and disembarkation intervals, future vessels can be adequately planned and designed in accordance to capacity requirements with every instance in mind. Moreover, safety standards are likely to be further improved, especially with potential endorsement from SOLAS and FPP regulatory bodies.

IoT technology

As a result of architectural and onboard analysis in the context of small and large-scale liners, at Paromat, we have developed an IoT technology to monitor passenger movement in real time with remote surveillance capabilities. Our system adopts sensing through the main footfall areas of passenger vessels, using facial recognition and laser count movement, which is integrated into the main interior fabric of the public spaces. Through a content and data analysis platform, we are able to heatmap monitor and quantify passenger movement directly with the vessel.

This allows crew members to essentially plan in real time the embarkation and disembarkation intervals by managing crowds instantaneously, as well as directing passengers to 'revenue generating' environments within the cruise ship. This system also accommodates an audit trail of footfall analysis and passenger count tracking. By allowing facilities managers to foresee heavy traffic environments, the technology offers predictive maintenance and real time reporting – reducing the loss of passenger loyalty long-term, as well as the high costs for last minute onboard repairs.

With the introduction of our technology, we foresee further capabilities for connectivity and real time analysis with the inclusion for IoT asset management – allowing operators to track onboard equipment to ensure reliability and efficiency in operations. The result, a fully integrated and connected passenger marine ecosystem, enabling crew and operators to analyse and control real time onboard data by ensuring smooth operations, constant revenue, maintenance standards, and passenger loyalty is retained at all times.

About the author

Matthew Jensen began his career as a trainee quantity surveyor specialising in power generation, ME systems, civil engineering and marine projects. He is the founding director of Paromat IoT Technology and Fraiserline Architecture, a multidisciplinary consultancy that provides services in the commercial, residential, marine and hospitality sectors. *NA*

The Boldrewood Towing Tank

Bertrand Malas gives an insight into the history and design of the University of Southampton's new towing tank, located at its Boldrewood Innovation Campus

Fig. 1 Construction (February 2014)

Built in 1975, the first Boldrewood Campus was dedicated to Medical and Biological sciences. In April 2006, the university announced plans to develop a 'professional campus' on the Boldrewood site, to house the marine services division of Lloyd's Register. In October 2010, the Boldrewood Campus was fully closed for redevelopment. From 2014 onwards, five buildings have been built and now host various engineering departments.

Discussions about the build of a towing tank started when the redevelopment of the campus was announced. In 2012, after the development had started, a crash in construction prices allowed the university to add the towing tank building in the existing construction budget, so it was quickly decided to go ahead. The main characteristics were agreed later that year and construction started in 2013 (see Figure 1).

The fit-up process for the Boldrewood towing tank has been a complicated journey with several delays, especially in the procurement of the carriage drive system. At the time this article is being written, the tank is scheduled to be fully operational in Spring 2020.

Design features

The Boldrewood towing tank is 138m long, 6m wide and 3.5m deep, which corresponds to just under 3,000m^3 of freshwater. Despite appearances, the bottom of the tank is flat [1]. The target maximum carriage speed was fixed to 12m/s, which is high for a facility of this size but gives the ability to run a wide range of experiments.

These dimensions were selected based on the experience of university staff, past recommendations [2] and the site's physical limitations. The length is the maximum achievable on site, due to the presence of a gas supply at the east end and a protected tree at the west end. These particulars form a good compromise for a facility designed to accommodate education, research, but also commercial experiments.

A review of existing and past towing tanks (see Figure. 3) shows that the Boldrewood tank is a relatively small facility, but it is by far the largest university towing tank in the United Kingdom, and within the top five in Europe. It is the first towing tank to be built in the UK since the late 1960s. The facility can accommodate models up to 6m in length, which is sufficient enough to obtain accurate results for most ship types.

The tank room has been designed without any windows to avoid direct sunlight on the water. This has been known to cause issues in some tanks due to re-circulating currents, thermocline or algae growth that can affect the quality and repeatability of the results.

The carriage design was developed through collaboration between the university staff and subcontractors. After considering several options, it was decided to go ahead with an aluminium monocoque carriage driven by two winches and two synthetic Dyneema cables. Although cable driven carriages have been operated in the past, it is believed that the Boldrewood carriage is the first dual cable system. It is expected that once the control system is fully tuned, this will allow a better control of the carriage motions, especially at low speeds where vibrations can be problematic.

The carriage was designed to be a flexible working platform. Equipment can be fitted under the floor with ease through lifting panels. The moonpool is large and allows good visibility for the users, and a lifting platform allows access to the model. The carriage is fitted with Rexroth panels to aid easy attachment of equipment.

The operation of the carriage was based on staff experience and past research about the effects of acceleration or deceleration on people in transport [3] [4] [5]. Table 1 details the expected different modes of operations for the Boldrewood carriage.

Towing tanks all over the world use different systems to damp the waves created by the model or the wavemaker between runs. These systems are very important as they increase the productivity of the facilities by reducing the waiting time between runs. It is usually achieved by the presence of an end beach, at the opposite end to the wavemaker, and in some cases by an additional system on one or both side walls. Over the last few decades, the university staff have extensively used the GKN tank on the Isle of Wight. It was decided to replicate the concept of an automatic side beach system on one wall, as was used there, as it is deemed to be the most effective one, although complex mechanically. The Boldrewood tank is fitted with 12 batches of five beaches each, controlled from the walkway or the carriage (see Figure 4).

A 12 paddle HR Wallingford wavemaker is installed at the west end of the tank. It is capable of generating regular and irregular waves with a maximum height of 0.70m and a significant wave height of 0.37m respectively. It can also generate oblique waves, which is not a conventional feature for a towing tank wavemaker, but it allows static experiments to be performed at varying wave angles using the underwater platform.

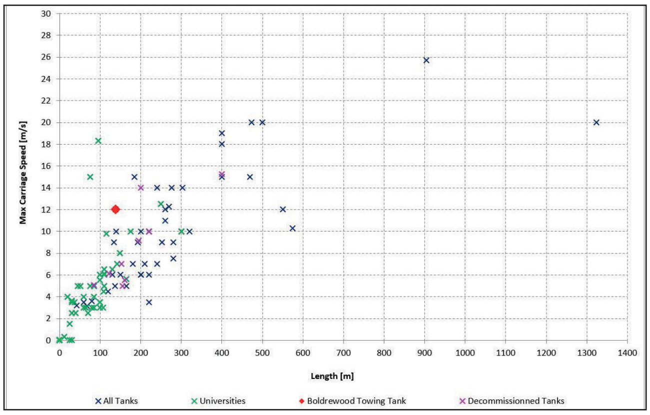


Fig. 2 Review of towing tanks dimensions

Mode of operation	I	II	III
Max. acceleration/deceleration	0 to 0.1g	0.1g to 0.2g	0.2g to 0.25g
Movement restrictions	None	People seated (not necessarily in a seat)	People seated and belted
Max. no. of people	10	10	6

Table 1 – Carriage operation modes

Table 1 Carriage operation modes

The rail alignment in a towing tank is a very important process and must be carefully thought through. Misaligned rails can lead to a bumpy ride and noisy measurements. The Boldrewood towing tank is fitted with 440 refurbished soleplates that were salvaged from the GKN tank on the Isle of Wight when it was closed in 2008. These soleplates allow for horizontal, vertical and roll adjustment of the rails. The rails were delivered in sections and welded in situ in January 2015 (see Figure 6).

A review of existing literature [2] [6] showed the following:

- The concrete should be allowed to settle in once the tank is filled with water. The Australian Maritime College (AMC) tank staff measured deflections of up to 1.2mm in the rail alignment within 12 months of filling the tank;
- A laser or telescope cannot be used due to the temperature gradient in the air;
- The rails must be aligned vertically to follow the curvature of the earth horizontally and in roll (in Southampton, the sagitta for an east to west orientated tank of 138m is about 0.6mm);
- The top faces of the rails must be level to within ±0.1mm over their length.

The tank was filled in June 2015. The rail alignment process was started in January 2016, as it was assumed this allowed enough time for the concrete to settle. The following methods were used, as recommended by the literature review and refined in house:

- A master spirit level with a precision of 0.02mm/m was used for roll adjustment;
- A 0.3mm Dyneema fishing line was attached to one bespoke winch at each rail end. This line has a breaking point of about 25kg and very little stretching, which allowed it to be pulled very tight and reduce the catenary effectively. A microscope was mounted on the rail to look down at the line and perform the adjustment with high precision (see A and B on Figure 8);
- The tank walls are fitted with a small trough in the concrete. This trough was filled with water (a surprising 600litres). Two steel pins were precisely machined. A datum bracket was installed at one end of the tank to adjust the length of the pins so that their pointy end just broke the surface tension of the water (see C and D on Figure 7). Another bracket was moved along the tank to the desired alignment location. Each pin was checked and readjusted to the datum on a regular basis due to the water level changing in the trough with evaporation.

These methods rely on the human vision, the rail alignment had to be performed by one single person. It took the towing tank technician David Turner about three weeks per rail to finish the alignment process. The Boldrewood towing tank only has a walkway on its south side, so the north rail alignment had to be performed from a floating pontoon, which made it more complicated.

The vertical alignment of the south rail was checked in 20 spots along the tank length in June 2016. This showed that the concrete did not move during that period.

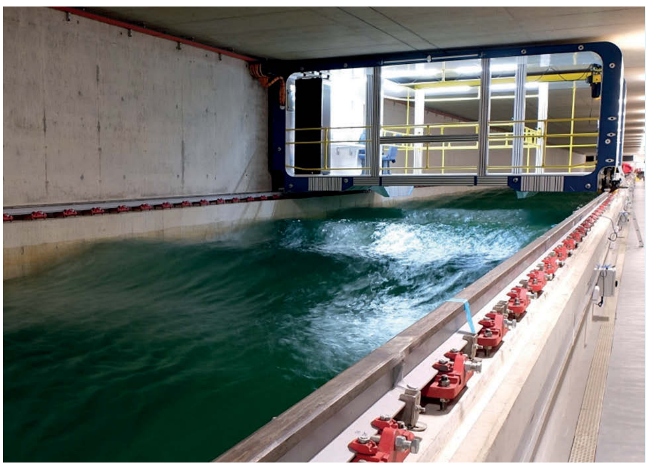


Fig. 3 View of the carriage

Other equipment

The Boldrewood towing tank is fitted with a water treatment system in order to maintain the water quality. This consists in two large sand filters, an ultraviolet lamp and a chlorine injection pump. The system is operated between 18.00 and 04.00 every night, so no recirculation currents are present in the tank during tests. The chlorine levels are monitored on a weekly basis and can be adjusted if necessary when humans are required to be in the tank, for example for swimming experiments.

The limited availability of large ocean basins for research and education has led the University of Southampton to purchase two Qualisys motion capture systems for the towing tank: one for above water measurements and one for under water measurements. The two systems can also be coupled for hybrid measurements. Using reflective markers, the measurements can cover single point trajectories in space or six degrees of freedom for rigid bodies. This technology is versatile and has allowed the university to develop new experimental methods used for various education, research and commercial projects [7].

The towing dynamometer was designed in house by the Wolfson Unit. This is a multiple tow posts design that can accommodate a large range of drag and sides forces, but can also measure heave, pitch, roll, roll moment and yaw moment. The dynamometer is suitable for all types of experiments and can accommodate small and large models.

A 6x2m underwater platform is installed in the tank, about 10m from the wavemaker, where the quality of the waves is best. This can be used as a lifting platform for large underwater vehicles or more often for mooring tests with ship models, wind generator buoys, wave energy devices or offshore platforms.

An underwater Particle Imagery Velocimetry (PIV) system was purchased by the university for the Boldrewood towing tank. This system consists of two cameras housed in a torpedo and a laser sheet. The tank is seeded with small particles and the PIV system measures 3D flow within the laser sheet.

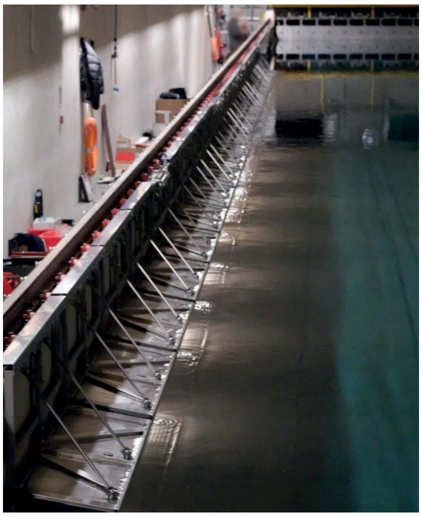
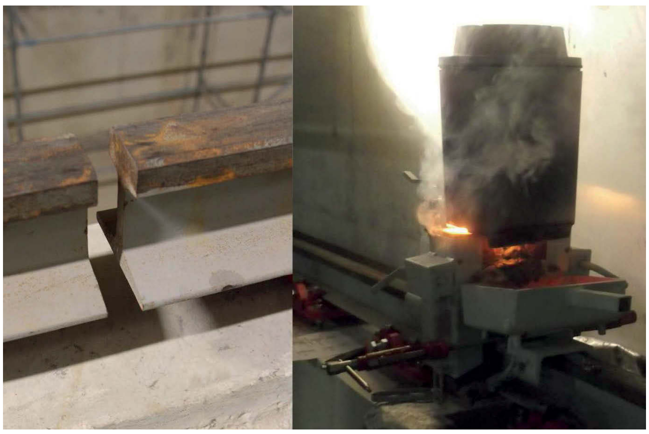


Fig. 4 View of the side beaches

Fig. 5 View of the wavemaker after installation

Fig. 6 Rail welding



Why would anyone build a towing tank today?

Amongst the 9,000+ visitors that have seen the tank since 2015, lots of people ask why the university has decided to build a tank in an age where computational fluids dynamics (CFD) is seen by many as good and mature enough to replace towing tanks. The question is widely discussed in various conferences and magazines in the marine industry. There have been several CFD workshops in the last few years [8] [9] [10] [11] where participants performed CFD calculations on a given hull geometry and benchmark their results against the model tests and/or sea trials results. Looking at the most recent workshops results for calm water resistance, they show large scatter in the results (between 10% and 15% for the Lloyd's Register workshop [10] and ±10% for the Sailing Yacht Research Association workshop [11]). A study performed by the International Towing Tank Conference in 2014 [12] shows that when performed according to the ITTC guidelines, the uncertainty of resistance model tests should be 2% or less. Although CFD is a great tool in the early design stage of ships, especially when it comes to hull form optimisation, these results show that scale model experiments still have and will continue to have a major role to play in the marine industry. CFD results for more complex problems like propulsion, manoeuvring or seakeeping should be treated with even more care, but these are areas where well established experimental procedures have been in place for many years.

The Boldrewood towing tank has been designed with flexibility in mind, so that a wide range of experiments in various domains can be performed in addition to conventional towing experiments, in particular for education and research. To date, the facility has been used for experiments in domains such as sailing (see Figure 9), wave energy, offshore wind, sports engineering, shipping, autonomy and biomechanics. This facility is a great asset to allow students across the whole Faculty of Engineering and Physical Sciences to have exposure to physical experiments and their associated procedures (preparation, calibration, scaling, analysis, etc). At a time when engineers spend most of their time working on computers, it is very important for students to acquire practical knowledge and to understand the importance of validation data for any numerical simulations they may undertake.

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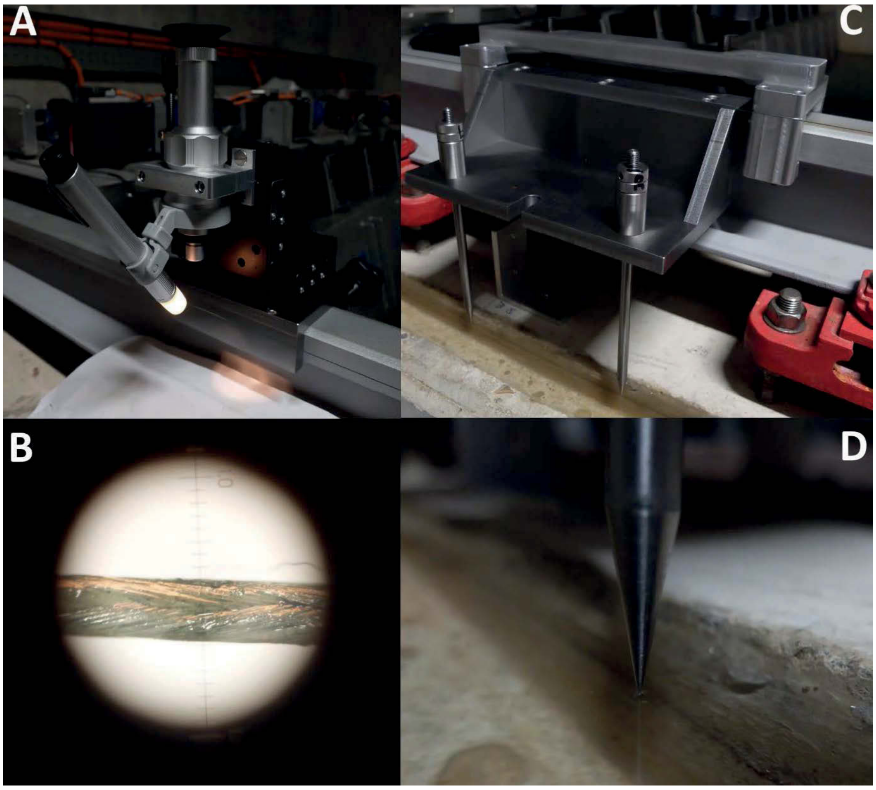

Fig. 7 Rail alignment techniques

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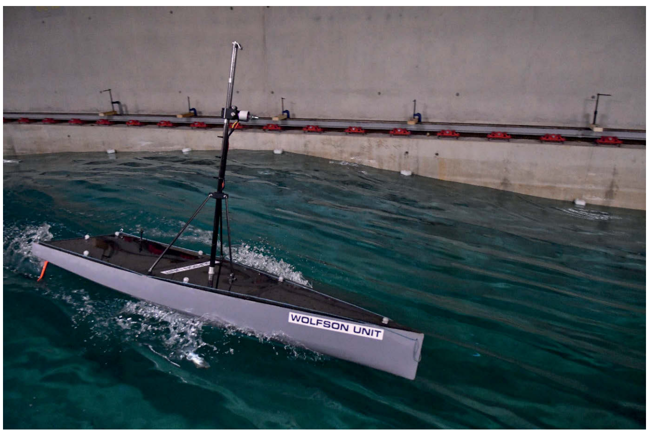


Fig. 8 Motion capture experiments on a free-running sailing yacht (13)

Applying BIM to cruise ship design

Building Information Modelling is well established for land-based architectural projects, but a recent project led by YSA Design suggests the process might also be a good fit for maritime

Construction projects, whether buildings, infrastructure or ships are, suffice to say, complicated undertakings. Naval and civil architecture alike have always required division and specialisation of labour, but the exponential advances in technical complexity have made it imperative to develop processes that minimise repetition, downtime and costly mistakes.

One such process that has risen to prominence is Building Information Modelling (BIM). In a nutshell, BIM entails the generation, management and sharing of digital representations of a building's various components that include both physical and functional characteristics, i.e. the wealth of supporting metadata behind a building project's physical appearance.

Although the concept has loosely existed since the 1970's, BIM didn't truly go mainstream until the turn of the century, as some of the major architectural software companies such as Autodesk, Bentley Systems and Graphisoft began embracing it as a common term. In particular, it became a synonym for collaboration within a common 3D model, with the enhanced understanding that offers over 2D drawings. Within a few years BIM had become so integral to construction projects that it was mandatory when bidding for government contracts for most countries in Scandinavia and central Europe.

Pioneering project

Despite the obvious parallels, ship construction has largely shied away from such an approach. But late last year, Norwegian architectural firm YSA Design announced it was close to completing what it says is the first cruise ship construction project to bring together everything from initial sketches to the sign-off tasks for utilities completion under the BIM process.

Georg Piantino, YSA Design

The owner of the undisclosed vessel was keen to explore the accuracy and efficiency benefits of using uniform 3D modelling for all stakeholders in every stage of the project. Although YSA Design is most closely associated with cruise ship interiors in the maritime sector, its experience with land-based BIM projects made it an ideal choice not only to produce 3D drawings of the whole ship (using the Autodesk Revit modelling software), but also to oversee the entire process on behalf of the client as the BIM Coordinator.

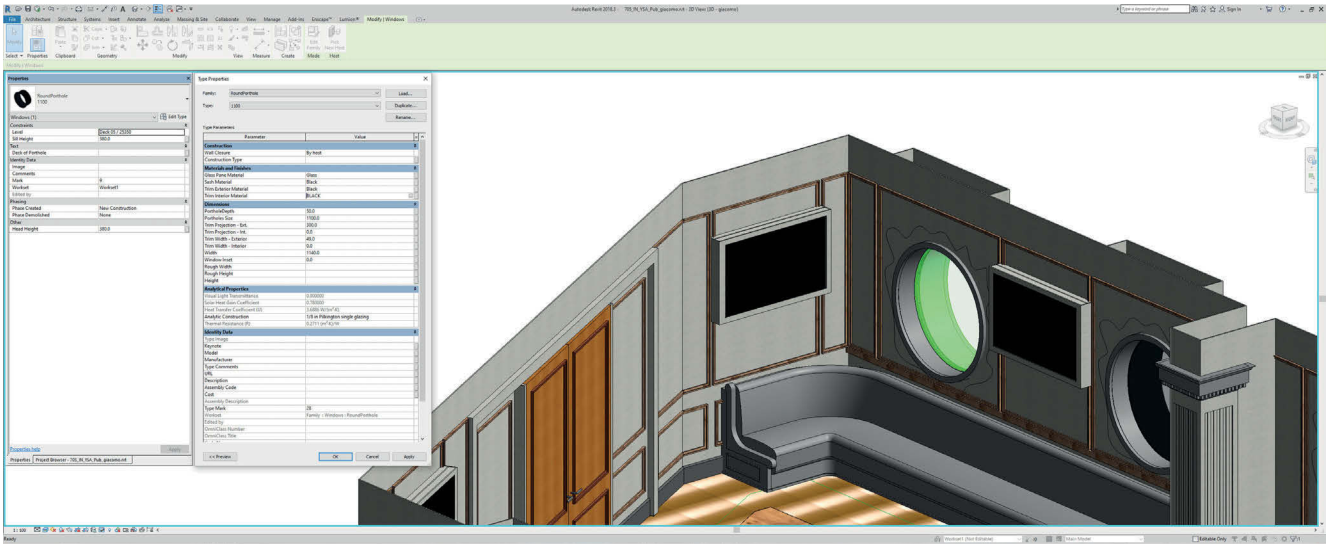
"We were recommended to draw the whole ship in 3D, from top to bottom," explains Georg Piantino, senior architect, YSA Design. "But with BIM, when a contract is signed, and an agreement to work in 3D, then you must also assign one person or group to act as the BIM Coordinator. That [Coordinator] could be the client itself, or the shipyard, depending on how technically minded they are."

Piantino thinks that, compared to other industries, shipyards are a little bit behind with BIM; they are also notoriously protective when it comes to their steel drawings. However, because the owner was keen for detailed information to be made available at an early stage, there was a much higher degree of cooperation than is often the case. "If the shipyard is early in supplying us the drawings it's much easier to communicate between all the different parties, because we have to start with the framework and build our architecture around it."

Establishing BIM rules

The BIM Coordinator's responsibility is to take all the different suppliers' models and create a BIM Manual, which is sent out before the project starts. This establishes the routine of the model sharing process. For example, where files are to be downloaded from, the location of the project server and which day of the week new files should be uploaded, so that every supplier knows when to upload their latest version. The project participants used the Autodesk-based Shipbuilding & Offshore software solution so that they all kept the entirety of the ship in mind throughout the project. All the participants have the same up-to-date information to ensure smooth coordination.

Although many outfitters, plumbers and electricians are already drawing in 3D, many still don't feel comfortable about sharing plans in this way. "We sometimes get 2D drawings that have been laid out in 3D but then exported and shared so that it looks like a 2D printout," says Piantino. "Traditionally, when you get the steel drawing you would then sketch the outfitter drawing above or beneath it to figure out if there is any collision, then physically make a



YSA used Autodesk's Revit platform for the project's 3D modelling

red line comment on the drawing and send it back to the shipyard."

3D modelling makes the process far quicker and more accurate by allowing the user to run a clash report which highlights areas where there is a collision. These collisions are highlighted in red, yellow, or green based on their severity.

"But with 3D drawings we can input them directly into our model and automatically generate a clash report. So the system helps us figure out where, for instance, the outfitter unit crashes into the construction unit. That might just be a 15-20mm bracket that is sticking out, which would only be a yellow collision, but it's something we might not see in a two-dimensional drawing."

"In the old days people might come to the vessel with the units and have to cut out a piece so that it fits into the construction. Now, because the collision report alerts us before it's produced they can remove this piece beforehand so that it fits perfectly."

Because the BIM is intended as a lightweight model (i.e. not data heavy) it is easy for different users to make their own sections and elevations, zooming inside the model to check the positions of features such as ventilation. This helps very much in understanding the design intention,

"You might discover that the air intake is 20mm beneath the height of the ceiling. So you would make a note and send it back to the file and the following Friday you check and see that it now fits perfectly. As the BIM Coordinator you slowly figure out the process and learn the right person to contact to get things done, but as a project partner your only responsibility is to ensure that every Friday by 12.00 you've sent the newest model from the area you're contracted to," explains Piantino.

Another example he cites is the design problems that can arise when a stairwell meets the next level. "Instead of making your own elevation you go into the BIM model, take the last drawing from the shipyard then add your architecture, carpet, noise cancellation layers on top of that and see whether you fall above or beneath the correct level."

VR friendly

For shipowners, who often have little understanding or time to spend reviewing traditional drawings, working with BIM holds the additional advantage that it can be complemented with virtual reality (VR) software that makes it possible to experience the space in a more digestible form. Piantino says the application of VR is an aspect of the BIM process he's particularly passionate about.

"With the VR glasses on you can go through the project and really see one-to-one how the room feels and where the problems may be. Then using the pointer you can click on an area to find out what material is being used. The display will bring up a little note saying, for example, that you're 'standing' on a marble floor of $25m^2$ and 60mm thick. Or you might click on a chair and find that 500 of that model have been bought for the whole ship, so it becomes easier to do cost calculations for the owner.

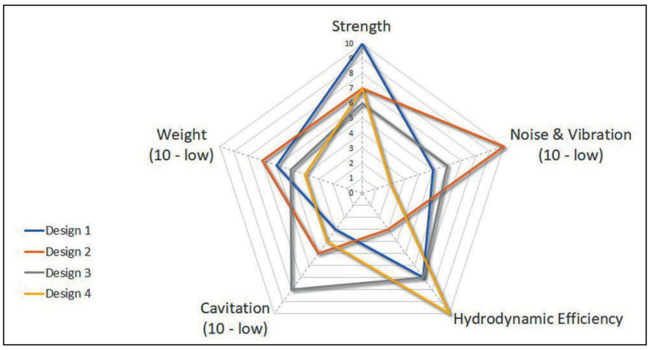
"When a client is wearing the glasses you can walk around with them and they can point out things that they want to discuss. What a particular material is or why a certain corner is jumping out. You can then share this on a video conference in real time with people all over the world."

As the project is ongoing, it's still difficult to arrive at a clear idea of the time and cost benefits of the BIM process to the entire project. However, Piantino thinks the most significant differences were felt during the earlier stages, given that the finished product had been created in its virtual 3D form before steel cutting had even commenced. Moreover, the experience of managing an entire shipbuilding project in 3D – both interiors and exteriors – promises to open up new business opportunities for YSA.

He adds that looking ahead he hopes to further refine the BIM process, particularly with stricter coordinating rules for the participants. "It's not all positive but we're winning time in man hours. Shipowners and suppliers are becoming more interested because they can see the benefits." *NA*

Out of sight, but not out of mind!

Ian Godfrey, development design engineer at Teignbridge Propellers, outlines a holistic approach to propeller performance



'Horses for courses' – different propeller designs target different performance criteria

Propeller performance can be defined by a number of metrics, from hydrodynamic efficiency and cavitation susceptibility to mechanical strength and noise and vibration. These performance criteria often pull in opposing directions, such that the right balance needs to be driven by the specific, weighted requirements of each customer and the propeller geometry defined to meet that specification.

Until recently, propeller design was driven by empirical data and long duration trial and error improvement and was viewed as a dark art by those on the outside looking in. Teignbridge utilises new, powerful simulation tools to understand the interaction between the propeller structure and the high-velocity fluid flowing around its complex surfaces.

This enables our designers to complement 45 years of experience with performance evaluation before the design leaves the engineering office, let alone gets wet. Initially the preserve of big ship propellers, these tools are now available to the sub 2.5m diameter propeller market. With a clear customer specification and powerful tools to predict performance, our designs can intentionally target areas of specific areas of performance.

Noise and vibration performance

In addition to reviewing basic design principles such as blade passing rates and propeller to engine matching, designers can now explore more complex sources of propeller noise and vibration performance. This work requires the simulation and evaluation of a variety of complex phenomena relating to cavitation, pressure distribution in the fluid surrounding the propeller, and transmission of vibration and noise through the fluid and vessel structures.

One-off boat designs and varying vessel mission profiles mean that almost every application requires a bespoke approach. The following are just some of the tools and methods available to designers to explore these phenomena in ever-increasing detail:

Cavitation noise: Most highly loaded propellers will cavitate, and whilst erosive cavitation (causing damage to blade surfaces) is often the principal area of concern, the presence of cavitation (erosive or not) can also represent a problematic source of broadband noise. Transient computational fluid dynamic (CFD) simulations can be used to simulate the location, extent and type of cavitation.

In order to manage computational time and effort, this will typically mean inferring regions of cavitating flow from the cavitation number (ratio of local pressure drop to fluid kinetic energy in a region of flow). Although where problems get very complex, a two-phase simulation can be used to simulate the vapour/gas-filled voids that form in the fluid during cavitation.

Trailing edge vortex shedding: Von Kármán vortex street shedding from the trailing edge (TE) of a propeller blade can cause excitation of the propeller's natural frequencies (see note below), resulting in strong tonal noise emission from the propeller. Hand calculations, 2D and 3D CFD simulation can be used to identify problematic trailing edge geometry and make targeted changes to avoid problematic vortex patterns.

Propeller natural frequencies: Structural finite element analysis (FEA) can be used to carry out a modal analysis on the propeller, identifying mode shapes and frequencies (not forgetting the effect of submergence in water on frequency). Determining correlations between sources and locations of excitation (including TE vortex shedding) and propeller natural frequencies can be key to identifying and avoiding problems.

Underwater radiated noise: It is now possible to place digital 'hydrophones' in the CFD simulation domain, enabling conversion of time-varying pressure distribution in the fluid to an estimate of the frequency and amplitude of underwater radiated noise.

The above is a snapshot of what is possible with advanced simulation tools and methods. Each propeller application will have different risk factors that need exploring to maximise performance in relation to propeller noise and vibration.

Why go to the effort?

Propeller geometry is necessarily complex (don't buy a propeller with straight edges!) with inter-related parametric definitions of pitch, skew, rake, blade section and more. Navigating the available design space to drive performance in a particular direction whilst operating in the complex wake of a boat is not a simple or a quick task, but Teignbridge is dedicated to getting it right. The approach pays dividends in fuel, noise and vibration reduction and overall customer satisfaction.

Propellers are the last and vital connection between your power plant and the water. Demand more performance from your propeller designer and be prepared to pay a little more for it – it will be money well spent. *NA*

Combating climate change: can naval architects do more?

Complex floating structures are the answer to the global climate change crisis, argues Lim Soon Heng, founder and president of the Singapore-based Society of Floating Solutions

'Oceanix City', a floating city concept unveiled at the UN last year, is designed to accommodate 10,000 people at sea

Engineers, in the ultimate analysis, are the culprits of climate change. The industrial revolution of the last 200 years has had the unintended consequences of polluting the world with greenhouse gas. True, engineers deserve credit for inventing the steam/gas turbine and the internal combustion engine but unwittingly they also have let the genie out of the bottle: the dire consequence of global warming.

The evidence of a hotter planet is clear: raging fires, melting polar ice caps and permafrost, exceptional floods, droughts, and hurricanes. Life on land and in the ocean has been decimated, biodiversity compromised, and food security endangered. Yet even as the world gets warmer, engineers are at the forefront of hydrocarbons extractino from the earth's crust and ocean bed to feed those machines.

One way to get out of this conundrum is to build in the sea what man has been building on the land. Floating complexes, be it offices or industrial estates, abodes or institutions, are environmentally more sustainable.

However, it is not in the DNA of homo sapiens to live on floating structures. Perhaps it is because their evolution took them along a path of hunting, gathering and tilling; fishing was a marginal activity. But there is also something in their psyche that links water with danger and drowning. It is a primordial instinct.

Naval architects are the best people to explain that such fear is irrational and living, working and playing on floating surfaces on the sea can be just as safe as on land, perhaps even safer. With cruise ships, offshore oil rigs and FPSOs to testify to their achievements, their assurance would carry more weight than any other profession.

Living sustainably

There are many reasons why living on the surface of the sea is more environmentally sustainable. Floating cities need no highways and bridges. That helps to reduce the enormous carbon footprint of the building material industry, which according to World Green Building Council amounts to 39% of global energy related carbon emissions.

What do you do with a building after it has served its purpose? Knock it down, cart away the debris, re-do the foundation and build a new one in its place. On the water you tow it away, repurpose and give it is a new lease of life. Extending the life

Keppel's concept design for its 'floating data centre park'

of a building is a 'greener' option that wastes less energy.

Water transport is more energy efficient. To move 1000tonnes of material from A to B would require about 50 trips by truck but only one by a medium size barge with the power of one truck.

The phenomenon known as the Urban Heat Island (UHI) effect is the blight of many cities. Air conditioners suck in the heat ejected by other air conditioners. On a floating structure, the heat of air conditioners is ejected directly into the water on which it floats. As the heat absorbing capacity of water (specific heat and thermal conductivity) is much higher than air, the physiological discomfort is less and the need for air conditioning reduced. The effect of large water bodies on UHI has been studied extensively and proven to be salutary.

While land architects and engineers are dabbling with floating simple abodes (essentially glorified boat houses), few have the credibility to develop working designs of complex mega floats with a waterplane area exceeding half a hectare and air draft higher than 25m. For seasoned naval architects, these dimensions are anything but challenging.

Below are some examples of floating structures that could result in lowering carbon emissions…

Data Centre

The Internet of Everything will one day soak up 10% of all the energy produced in the world through data centres, just to keep the servers from overheating. These data centres eject heat into the atmosphere causing its own heat island, and guess what? Others around the heat island will attempt to counteract by having larger air conditioning systems, leading more heat emission.

For this reason, data centres floating in the sea make sense. Dumping heat into the sea by pumps and heat exchangers is more efficient than into the atmosphere with fans and cooling towers.

The technology is embryonic; like oil rigs in the 1970s. Much can be done. The market is enormous if such systems become the norm as the demand for data storage grows exponentially.

One idea fascinates me. I would recommend RINA form a task group to investigate the possibility of using the waste heat from data centre to generate electricity through the process known as Ocean Thermal Energy Conversion (OTEC). Possibly a data centre mounted on a spar over deep water? Who knows; such a hybrid OTEC-DTEC, to coin a new acronym, could be a net power producer instead of consumer?

Floating nuclear power plant

Floating nuclear power plants are common. The US alone has 83 nuclear-powered ships, 72 submarines, 10 aircraft carriers and one research vessel. Russia commissioned its floating nuclear energy power plant in December 2019. The Massachusetts Institute of Technology (MIT) is working on a spar hull Offshore Nuclear Power Plant. These are forerunners of a new energy system inspired by the need to reduce carbon emission.

Nuclear energy is the cleanest base load energy system there is, but the image of the Fukushima nuclear disaster is still seared in the minds of too many for it to be taken seriously. All three nuclear reactor meltdowns the world has witnessed, Fukushima, Chernobyl and Three Mile Island, would not have occurred if the cooling water supply had not failed.

A floating nuclear reactor sitting below the water line can hardly experience a meltdown as the cooling water system does not require external energy input to activate it.

However, nuclear engineers need the best advice there is for the design of appropriate hull forms and mooring systems. Perhaps RINA can play the role of linking up naval architects with designers of nuclear reactors and explore how their resources can be combined to design safer floating nuclear plants.

Others

The superior sustainability of floating structures is not confined to energy related assets. Farm produce is more sustainable when grown on floating structures. Wind, sun and current are energies that can be harvested to support such farms and transporting farm produce in bulk is more energy efficient with barges than with trucks. Moreover, floating farms with water stored below deck are more resilient to floods and droughts.

Industrial plants and warehouses should be erected offshore so that they need not compete for land, especially in high density urban areas. For the same reasons, infrastructures such as ports and airports, shipyards, cruise centres, golf courses and university campuses are also good candidates for offshoring.

Urban decay, a pressing problem in cities from New York to Bombay, would be more manageable when cities are afloat than on land because structure can be removed, relocated and repurposed sustainably without resorting to the wrecker's ball or explosives. No building can be greener than one that is floating as it can last twice as long.

Conclusion

A community that lives on the surface of water is more carbon neutral than its counterpart on land. Naval architects can and must expand their vision beyond their conventional horizon. They are well placed to take the lead in a movement to make better use of the seas around the world, as well as to combat climate change. *NA*

For more info visit: **floatingsolutions.org**

Stability without formulas: 'KG-CB' diagrams in polar coordinate system

The form is simple, but the dependencies are very complex, explains Eugeniy Oberemok

For the vast majority of publications dedicated to stability issues, the transverse metacentre is set in the mid-section of vessel and with rare exceptions in Centre-Line plane (CL). Such positioning is erroneous and can be acceptable as simplified representation, but warrants specific reservations.

The transverse metacentre will be set in CL if the waterline is unchanged during to heel of the hull. And this is only possible for hull shapes with a cross section of a circle or close to a circle. Such forms of hulls are found in some antique sailing ships, such as those found in 18th century or some special designation projects (for example miltary vessels or icebreakers).

The inclinations of equal wedge volumes of the ship's hull should be considered of fundamental importance when considering stability issues and the most suitable object shape to review this is a pontoon-parallelepiped which has all coefficients of fullness (CB, CP, CM, CWP) equal to one, even keel and the ratio D/d=2 (for example, breadth of ship B=20 m, depth D=10 m, draught d=5 m.).

When the pontoon is inclined, the waterline initially moves within the straight sides. In this case, classic inclinations of equal wedge volumes are formed, and the heel of hull happens against the longitudinal axis of hull's symmetry.

As the pontoon tilts with increasing width of the waterline, the metacentric radius 'MB' also increases. The centre of buoyancy (C.B.) and the transverse metacentre M_T moves along a complex trajectories (the involute and the evolute) and the width of waterline and 'MB' reaches its maximum values when the list is 26.57° when the deck submerges into the water.

When the rectangular pontoon is tilted, its C.B. moves in the mid-frame plane along a complex nonlinear path. The C.B. paths are shown in Figure. 1 (the path of deck submerges into water marked by blue colour, the path of bilge emerges from water marked by red colour).

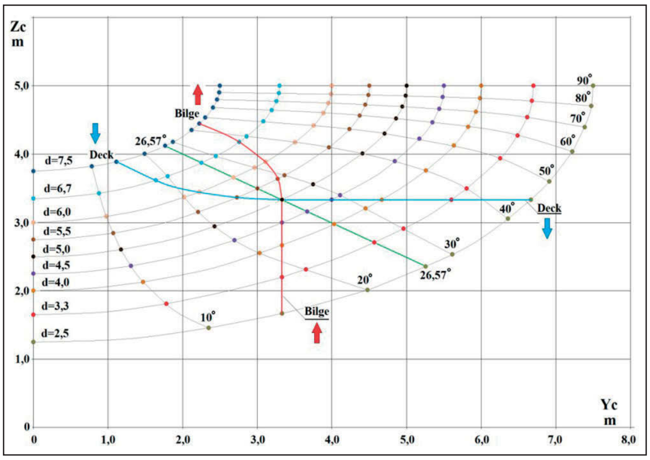


Figure 1: C.B.-curves of the pontoon for various draughts

The projection of metacentric radius from the side of inclination to CL is equal to initial metacentric height when pontoon has even keel, and this constant is maintained during the entire range of coextensive (equal-volume) inclinations until the deck submerges into the water (or bilge emerges from the water).

The change in the position of the metacentre MT and the movement of C.B. along the arc-shaped path "C'-C" with an unchanged value of "AB" at angles of heel ranging from 0° to 26.57° (AB=constant= 6.667m), are shown in Figure. 2 for the case in question.

Restless travellers

You could describe the Centre of Buoyancy and the Transverse Metacentre as restless travelers who constantly travel on different roads, but always strive to be settle on the common vertical. The

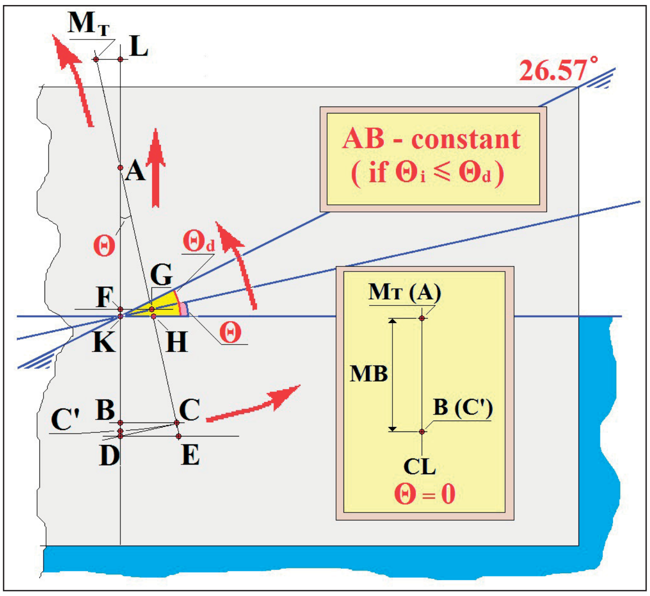


Figure 2: Shifting of C.B. and MT with increasing the list Θ of pontoon

point 'A' is called the Pro-Metacentre ("PMT" or False Metacentre) and is located at the intersection of the buoyancy force directed upward and the inclined CL.

When list is absent this point coincides with the transverse metacentre. With a list change, PMT moves along the CL along a complex path depending on the shape of the evolute.

With the apparent simplicity of contours of a rectangular pontoon, shaped as a parallelepiped, the following happens when its list changes:

- C.B. and MT even with zero different move along rather complex paths;
- the transverse metacentre with the appearance of the heel begins to shift from the CL to the opposite from heeled side and this shift will increase until the waterline intersects one of the corners of the pontoon hull;
- C.B. rotates around the transverse metacentre MT, which, in turn, moves along the evolute;
- the metacentric radius changes as the shape of the water line changes and crosses the CL with equal-volume inclinations in the Pro-Metacentre; the projection of the metacentric radius from the side of the inclination to the CL will be a constant value (leg AB = constant) and it will be equal to the initial metacentric height in the absence of roll; this constant will be maintained over the entire range of equal-volume inclinations up to the intersection of the waterline with one of the corners of the pontoon;
- the largest increase in the metacentric radius of the pontoon is observed at D/d= 2 for the list corresponding to the angle of entry of the deck into the water (intersection of the bilge with the waterline);
- a decrease in the relative radius at angles of heel more than 45° will be the same for all options for loading the pontoon.

Stability diagrams in the polar coordinate system

The results are unchanged if the resulting buoyancy force is depicted strictly vertically, perpendicular to the horizon (i.e., to the level of calm water plane), if the object itself is tilted, and not the waterline.

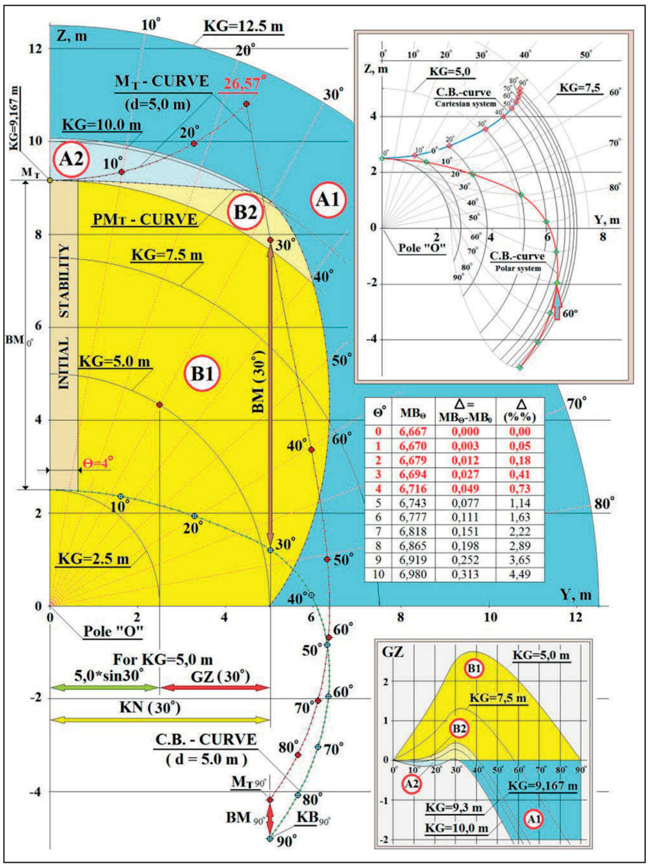


Figure 3: Zones of negative (A1), positive (B1) and variable (A2-B2) stability for draught 5m and the pole 'O'

Such a scheme is fully consistent with the actual conditions of inclination of the hull.

To clearly illustrate the changes in the basic stability parameters at various heel angles, it is possible to recommend the construction of DSS in the polar coordinate system.

If the pole is located in the KG (ship's centre of gravity) or in the C.B., the result will be the DSS for a specific loading option. However, a diagram with a pole, which is located on the CL-BL, can be of most interest. In this case, one can vary both CG and C.B. As a result, it becomes

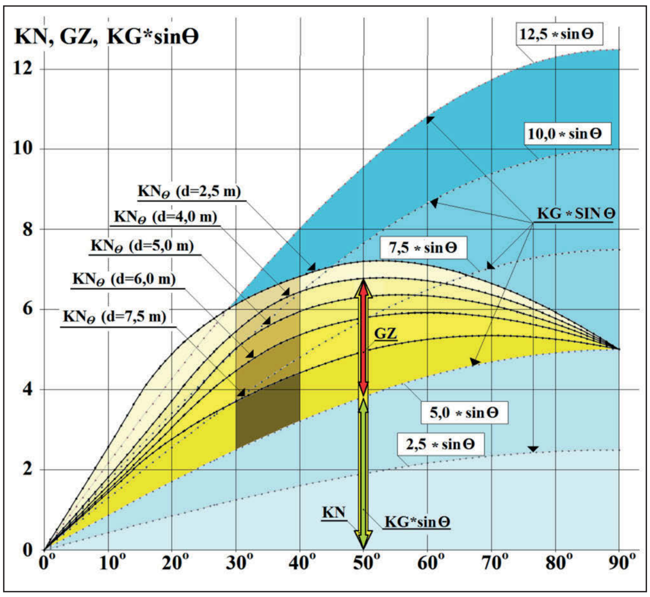


Figure 4: Universal DSS of pontoon for KG = 5m

possible to determine stability parameters in the entire inclination range for any draught and for any KG.

Figure. 3 shows (inset box in the top right corner) the path of C.B. of pontoon in polar coordinate system for d=5.0 m (highlighted in red – hull rotates, the waterline remains horizontal); in blue, the trajectory of C.B. in Cartesian coordinates is duplicated (the waterline traditionally rotates, and the hull remains unchanged).

The image of resulting buoyancy force is strictly vertical on the diagrams (perpendicular to the horizon) and the inclination of the object itself, and not the waterline, corresponds to the process of tilting the hull.

If the path of the transverse metacentre $M_T=f(\Theta)$ is plotted on the diagram, then we can illustrate the change in transverse radius BM, and the application of the allowable KGs of the pontoon at which the static stability arm GZ=0 allows us to determine the zones of positive, negative, and variable stability. Corresponding zones for a draught of 5.0m are illustrated on the diagram.

The same figure illustrates how the DSS changes with increasing KG (see DSSs in the lower right part of the figure) and also the zone of initial stability (the list up to 4°) is highlighted when the M_T and C.B. move almost parallel trajectories.

Universal DSS

The above calculation results show that for a pontoon of the simplest parallelepiped form and D/d=2, a list to one of the sides leads to the fact that all the main parameters affecting the restoring (capsizing) moment change along rather complicated paths.

With information on the trajectory of the C.B. and the position of the Centre of Gravity, it is possible to construct a universal DSS for the entire range of real draughts and KGs.

An example of universal DSS of pontoon for KG = 5m in the range 2.5-7.5 against the background of different "KGs*sinΘ"-curves is shown in Figure. 4 (with a selected area of 30-40° in accordance with IMO requirements and the example determination of GZ for Θ=50° and d=4,0 m).

If changing the base data (B/D, Cb<1.0, etc.), or introducing the trim, then all of the above graphs will undergo corresponding changes. *NA*

About the author

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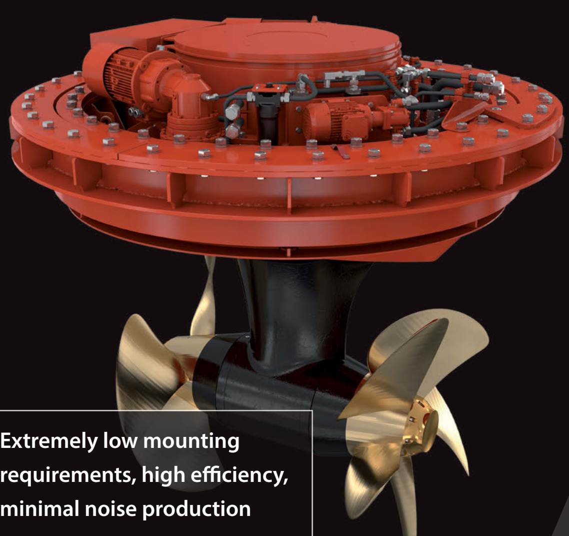

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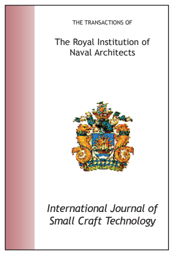

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Sub-Committee on Ship Systems and Equipment (SSE)
International conference,
IMO Headquarters, London, UK
www.imo.org/en/MediaCentre

March 4, 2020
Sustainable and Safe Passenger Ships
RINA conference,
Athens, Greece
www.rina.org.uk/Sustainable_and_Safe_Passenger_Ships.html

March 11, 2020
Damaged Ship V
RINA conference,
London, UK
www.rina.org.uk/Damaged_Ship_V.html

March 11-13, 2020
Sea Japan
International exhibition,
Tokyo, Japan
www.seajapan.ne.jp

March 11-13, 2020
Australasian Oil & Gas (AOG)
International conference
Perth, Australia
https://www.rina.org.uk/AOG%202020

March 11-20, 2020
Asia Pacific Maritime
International exhibition
Marina Bay Sands, Singapore
www.apmaritime.com

March 30-April 3, 2020
IMO Marine Environment Protection Committee (MEPC)
International conference,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

April 1-2, 2020
Autonomous Ships
RINA conference,
London, UK
www.rina.org.uk/Autonomous_Ships.html

April 22-23, 2020
Influence of EEDI on Ship Design & Operation
RINA conference,
London, UK
www.rina.org.uk/EEDI_2020.html

April 22-23, 2020
Postgraduate Research in the field of Maritime Industry
International conference,
Gdansk, Poland
www.cemt.eu/Post_Graduate_Conference.html

May 13-20, 2020
IMO Marine Safety Committee (MSC)
International conference,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

May 14, 2020
RINA Annual Dinner
RINA event, London, UK
www.rina.org.uk

May 27-28, 2020
Green Shipping
WEGEMT/RINA course,
London, UK
www.rina.org.uk/Autonomous_Ships.html

June 1-5, 2020
Posidonia
International shipping exhibition,
Athens, Greece
www.posidonia-events.com/

June 2-5, 2020
Basic Dry Dock Training Course
Training Course,
London, UK
www.rina.org.uk/events_programme

June 15-19, 2020
IMO Technical Cooperation Committee (TCC)
International conference,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

June 17-18, 2020
Warship 2020
RINA conference, Bristol, UK
www.rina.org.uk/events_programme

June 23-25, 2020
Autonomous Ship Symposium
International conference,
Amsterdam, Netherlands
www.autonomousshipsymposium.com/en/

September 8-11, 2020
SMM
International exhibition,
Hamburg, Germany
www.smm-hamburg.com/en/

September 23-24, 2020
Full Scale Ship Performance
RINA conference, London, UK
www.rina.org.uk/events_programme

October 7-9, 2020
Contract Management for Ship Construction, Repair & Design
RINA Conference, London, UK
www.rina.org.uk/events_programme

October 19-23, 2020
IMO Marine Environment Protection Committee (MEPC)
International conference,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

October 14-15, 2020
Smart Ship Technology
RINA conference, London, UK
www.rina.org.uk/events_programme

November 4, 2020
Ice Class Vessels
RINA conference, London, UK
www.rina.org.uk/events_programme

November 16-20, 2020
IMO Maritime Safety Committee (MSC)
International conference,
IMO Headquarters, London, UK
www.imo.org/en/MediaCentre

December 2-3, 2020
Historic Ships
RINA conference,
London, UK
www.rina.org.uk/events_programme


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