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THE NAVAL ARCHITECT

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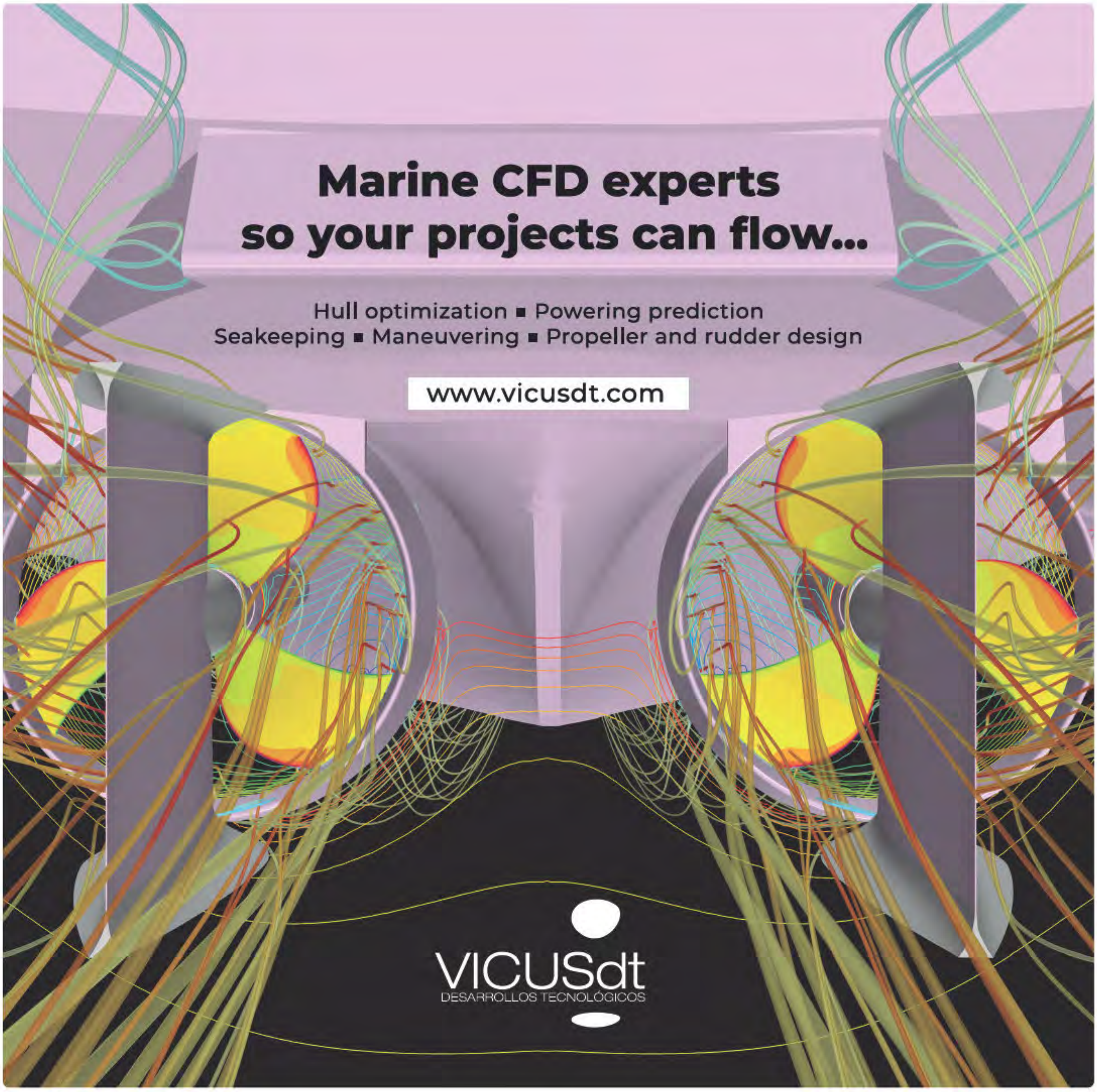

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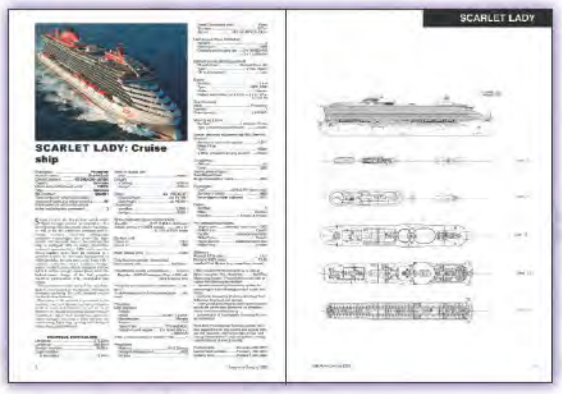
SIGNIFICANT SHIPS OF 2020



Published in February 2021, *Significant Ships of 2020* brings together more than 35 notable newbuildings delivered during the previous year. As ever, the publication will feature general arrangements, concise descriptions, in-depth particular details and photographs of each vessel. Vessel types will include:

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Comprising around 25-30 first-in-class vessels under 100m in length delivered during the year, the 2020 edition of *Significant Small Ships* is published in February 2021. Featuring general arrangements, ship descriptions, technical particulars and photographs, the publication covers a wide range of ship types, including:

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'Frankenstein fuel' or fear mongering?

Wakashio's grounding in July 2020 has raised some uncomfortable questions about the possible role of VLSFO. Source: IMO

A few months ago (*TNA* Nov 2020) I used this column to bemoan the challenges of being a maritime journalist and I ought to begin by thanking those readers who gave me some very positive feedback. I mentioned at the time that a publication such as this one exists in a wider ecosystem, a symbiosis with the wider marine industry and its communication channels. The same doesn't tend to apply when it comes to mainstream media coverage of shipping; there's less need for diplomacy and that can have both positives and negatives.

As many will remember, in July 2020 the Japanese bulk carrier *Wakashio* ran aground off the coast of Mauritius, gradually breaking up and spilling an estimated 1,000 metric tonnes of fuel oil. The incident has been described as the worst environmental disaster ever experienced by the island, causing huge damage to marine fauna, with some reports suggesting the insurance payout could reach up to US$10 billion.

Among those who started investigating was Nishan Degnarain, an economist and regular contributor to the business journal *Forbes*. After it emerged that *Wakashio* was carrying very low sulphur fuel oil (VLSFO), Degnarain's coverage increasingly focused not only on how little was known about VLSFO's potential environmental impact, but also the role this "Frankenstein fuel" might have played in the causes of the grounding itself.

In December, with the help of satellite analysts Geollect, Degnarain reported evidence of changes to the voyage plan in the days leading up to the incident that imply *Wakashio*'s operators, Mitsui OSK Lines (MOL), may have been aware of a problem. More recently unearthed evidence further suggests the vessel drifted for several hours prior to the grounding at a 90 degree angle, something consistent with engine failure. The cause, Degnarain suggested, may have been off-spec VLSFO. Last month, BP, which supplied *Wakashio*'s VLSFO, rejected what it described as "baseless accusations", while MOL has called the *Forbes* report "seriously flawed" and said the ship's fuel was on-spec.

Another article detailed a quasi timeline to what Degnarain (or at least a publicity conscious *Forbes* editor) dubs "Shipping-gate", looking at the history of the sulphur cap (as well as some tenuous connections to last year's fuel price crash in the wake of Covid-19). In particular, he is damning of IMO for its prevarication, accusing secretary general Kitack Lim of 'betting' on VLSFO being the way forward when the sulphur limit was approved at MEPC 73 in October 2018. VLSFO, Degnarain claims, effectively didn't exist before this time.

Regular readers are probably tired of hearing me refer to the debacle of the Ballast Water Management Convention, but there's no question that the criticism surrounding the protracted implementation of that regulation galvanised IMO, and particularly Lim, when it came to the sulphur cap's hard deadline of 1 January 2020. Moreover, very low sulphur fuel blends had been in regular use for the best part of five years and many of the problems – volatility, cat fines, viscosity and wax deposits, to name a few – were already well-known and widely discussed long before last year. Might IMO have imposed stricter requirements in terms of testing and verifying the compatibility of different VLSFO blends? Possibly, but historically the onus has always been on shipping's ability to self govern and the cooperation of all stakeholders.

There is, quite rightly, anger at the damage caused off the Mauritian coast and desire to find those accountable. At the time of writing, the United Nations Human Rights Agency (UNOHCR) is in the midst of an investigation into whether the toxicity of chemicals used in VLSFO might constitute a human rights violation. There is also, again quite rightly, suspicion that ship operators, oil majors and possibly even regulators might collude to conceal the facts about the safety of low-sulphur fuels, or at the very least be guilty of criminal negligence. Put bluntly, some of those involved have a penchant for conducting their affairs with less than complete transparency. Added to that are the wider societal concerns about the 'greenwashing' undertaken by some major corporations.

But at the same time, there is the need for fair and independent investigation; confronted with the kangaroo court of social media and clickbait culture it's more important than ever not to give ground to mob rule (we only need to recall the scenes in Washington DC a few weeks ago).

Finally, let's not forget that desulphurisation of fuels is also helping to reduce pollution and save lives. A paper published last year by the International Journal of Environmental Research and Public Health into the impact of Baltic shipping emissions concluded that the 0.1% limit in Baltic Sulphur Emission Control Areas (SECAs) had reduced premature deaths in coastal areas by approximately a third (over 1,000 cases) in 2016, one year after its introduction. It has been proven more than once that environmental policies can and do make a difference. *NA*

Container ships

Container ships suffer huge cargo losses

The safety of container ships is again in the spotlight after several serious incidents throughout December and January, with a massive number of container losses taking place during heavy storms in the Pacific.

On 3 December, it was reported that the 14,000TEU *ONE Apus* had lost approximately 1,900 containers overboard, some carrying dangerous goods, while travelling from Yantian, China, to Long Beach, California. The 2019-built vessel, which is part of Ocean Network Express's (ONE) Far East Pacific 2 (FP2) service, suffered a stack collapse during gale force winds and large swells. No crew were harmed and on 8 December, *ONE Apus* berthed at Kobe, Japan, where offloading of cargo and repair work commenced. Initial estimates by insurers put the financial cost at US$200 million.

Then, on 16 January, approximately 750 containers were lost overboard from the 13,100TEU *Maersk Essen* (built 2010) during what was described as a "rough sea encounter" while en route from Xiamen, China, to Los Angeles. Again, there were no reports of casualties and at the time of going to press *Maersk Essen* was heading for Lazaro Cardenas, Mexico, for an initial cargo assessment and survey.

Further recent incidents include the loss of 76 containers from *E.R. Tianping*, on a chartered voyage from South Korea and North America in January, and 36 containers from Evergreen Marine's *Ever Liberal* off the coast of Japan at the end of December.

In 2020, the World Ship Council Council calculated that an average of 1,382 containers had been lost annually for the last 12 years. The total for the past two months alone is thought to be close to 3,000 containers.

Maersk Essen, pictured in 2011. Source: Andy Nunn

Classification societies

DNV GL reverts name to DNV

DNV GL is to change its name to DNV with effect from 1 March, eight years after the merger which brought classification societies DNV (Det Norske Veritas) and GL (Germanischer Lloyd) together.

In a statement, DNV GL comments that: "The move comes after a comprehensive review of the company's strategy as it positions itself for a world in which many of DNV's markets are undergoing fundamental change."

It adds: "The 2020s has been called the decade of transformation or the "exponential decade", where the pace of the energy transition will be set and where food, health and transport systems will change immensely and digital technologies underpinning industry 4.0 will mature from experimentation into large-scale application."

Remi Eriksen, Group President and CEO, justifies the decision by saying: "It was not a name that rolled off the tongue, and many customers already refer to the company as DNV." He continues: "A simpler name will be an even stronger trust mark for our customers in the future, but still carries with it all our strengths and proud 157-year-old legacy with a purpose to safeguard life, property and the environment."

While still best known for its involvement in the maritime industry, like many classification societies DNV GL has increasingly diversified its assurance and risk management services over recent years.

Covid-19

Industry leaders sign Neptune Declaration to end seafarer crisis

More than 300 maritime companies and human rights groups have pledged to support a new Global Maritime Forum-led initiative designed to end the crew change crisis caused by the Covid-19 pandemic, it was announced on 26 January.

The Neptune Declaration on Seafarer Wellbeing and Crew Change consists of four main actions devised to facilitate crew while maintaining global supply chains:

- Recognise seafarers as key workers and give them priority access to Covid-19 vaccines
- Establish and implement gold standard health protocols based on existing best practice
- Increase collaboration among ship operators and charterers to facilitate crew changes
- Ensure air connectivity between key maritime hubs for seafarers

It is estimated that around 400,000 seafarers have been left stranded by the coronavirus pandemic after their initial contracts expired and they were unable to disembark. Notwithstanding the impact on their wellbeing, it has caused significant disruption to the safety and logistics of global sea trade. Among the Neptune Declaration's signatories are A.P. Møller – Mærsk, BP, BW, Cargill, Cosco, Euronav, MISC, NYK, Rio Tinto, Shell, InterManager and Lloyd's Register (LR).

InterManager president, Mark O'Neil, described the Declaration as a "huge step forward for seafarers", adding: "We have a shared responsibility across the entire maritime value chain to resolve this crisis as soon as possible. It's promising to have so many global industry and human rights leaders involved in these efforts, and that steps toward ending the crew change crisis are being giving such weighted leverage."

Nick Brown, CEO of LR comments: "Despite efforts being made by international organisations, unions, companies and governments around the world to resolve the crew change crisis, further action is urgently required. It is vital that we safeguard and protect the committed key workers who maintain our global maritime supply chain and have been on the frontline throughout this pandemic."

Shipbuilding

China returns to (dwt) orderbook top spot

Chinese shipbuilders have gained the advantage over their South Korean rivals for the first time in two years, at least in terms of deadweight tonnes (dwt), according to figures published by the Chinese Association of Shipbuilding Industry (CANSI).

CANSI says that new vessel orders totalling 28.9 million dwt were secured during 2020, a drop of 0.5% on the previous year, but representing a 48.8% share of the global market. Completed tonnage by Chinese yards rose by 4.9% to 38.53 million dwt (43.1%). The holding orderbook dropped by 12.9% from a year earlier to 71.11 million dwt (44.7%).

However, figures published by Clarkson Research Services in January, based on compensated gross tonnage (CGT) suggest that South Korea still has the upper hand, thanks in part to a late flurry of orders at the end of the year.

It says that Korean yards won orders for 187 vessels amounting to 8.19 million CGT (43%) during 2020, with China coming second at 7.93 million CGT (353 ships, or 41%). The Korean figures were bolstered in particular by demand for large LNG carriers, with 36 such vessels ordered in December alone.

Earlier in the month, Clarksons said that the global orderbook had dropped to its lowest level in 31 years compared to the existing fleet, falling to 53.9 million dwt, against 76 million dwt the previous year (see also p14-15).

Alternative fuels

ShipFC project targets ammonia fuel cells

A project that has secured a US$12 million grant from the European Union's Horizon 2020 research and innovation programme is aiming to prove the feasibility of ammonia fuel cells for deep-sea shipping.

ShipFC, with project partners including NCE Maritime Cleantech, the University of Strathclyde and operator Eidesvik, will see offshore vessel *Viking Energy* retrofitted with a 2MW fuel cell powered by green ammonia by late 2023, allowing it to operate for at least 3,000 hours annually on clean fuel. But the longer-term aim is to scale this up to far more ambitious 20MW fuel cell solution.

"Once the first phase of the project is completed, that's when the fun starts," explains Dr Michail Cheliotis, Research Associate at the University of Strathclyde, which is lead partner in the project. "The huge difference in scope makes ShipFC much more interesting than just a replication of Viking Energy... because a 20MW power plant requires significantly different treatment."

Cheliotis says the project will also consider a bulk carrier, offshore construction vessel and container ship, working closely with the respective shipowners to determine their particular requirements. ShipFC will also examine the ammonia supply chain. Bergen-based technology development company Protech will be responsible for the supply and installation of *Viking Energy*'s 2MW fuel cells. NA

Viking Energy. Image: NCE Maritime Cleantech

A new year arrives with new roads to follow

Covid-19 continues to overshadow all aspects of life, Malcolm Latarche writes, with recent announcements hinting that shipowners are looking towards their future options

It seems much longer than a year since shipping was beginning to absorb the effects of the IMO SOx cap and coronavirus was unheard of. The only inkling of what was to come were reports of a new type of pneumonia circulating in China. There have been some issues over the year with regard to new 2020 compliant fuels, but overall the carnage and catastrophes that some were predicting have not actually materialised.

The virus, however, has proven to be the most disruptive thing to have happened to shipping since the 1940s, an even bigger problem than the oil crises of the 1970s. It is hoped that the rolling out of vaccines may eventually bring an end to the issues of stranded crews and travel restrictions. Throughout January, there have been calls for seafarers and other essential maritime workers to be given priority but that does not seem to be happening as yet. In fact, with new variants of the virus developing, it would seem that many countries are actually raising barricades higher.

With the vaccines has come a rise in the price of crude oil and bunkers. However, it has been a stuttering upward trend rather than a sudden growth. Nevertheless, some are convinced that the rise will become sustained and it has pursuaded some owners to revisit scrubbers.

Following an increase in scrubber installations in 2019, the precipitous drop in oil prices caused some owners to postpone or even rethink their retrofit programmes. After MEPC 75 introduced the very real possibility in three or four years' time of a new efficiency measure for all existing ships to be subject to stringent new decarbonisation demands, many expected that scrubber sales would nosedive.

Certainly the EEXI concept has caused several owners to hesitate in ordering new vessels, but two major players in the container liner sector have been thinking big. Japanese operator ONE committed to six new 24,000TEU ships at the end of 2019 and in January, Hudong-Zhonghua won a contract to design and build a new class of ULCS vessels which will have a capacity for 24,100TEU. These are all planned to be energy efficient, but both contracts call for the ships to be scrubber fitted, suggesting that the owners are not yet ready to abandon HFO.

If the largest container ships now on order are set to be running on fossil fuels, other owners are exploring alternatives. Maersk's head Søren Skou said during a podcast in mid-January that Maersk would likely come with an order for a carbon-free vessel within three years. He hinted that initially it would be a small ship but with a concept that could later be scaled up. Intriguingly, a day or so later Norwegian shipbuilder Havyard reported that it had been approached by an unnamed European owner to develop a hydrogen-fuelled cargo vessel. In the announcement, Havyard said: "The goal is to design a large ship that can sail longer distances with zero emissions".

Not so long ago, hydrogen was considered to be the fuel of the future but more recently that position seems to have been claimed by ammonia. The main engine makers are definitely following that route and some shipowners are preparing for it too. US-based classification society ABS has already declared that it will be classing the first ammonia fuel-ready vessel in the world.

The ship in question is a Suezmax under construction for Avin International at New Times Shipbuilding in China. Currently being built as conventionally fuelled, the vessel complies with the ABS Ammonia Ready Level 1 requirements, indicating it is designed to be converted to run on ammonia in the future. There is no mention of the make of engine but since Wärtsilä is undertaking experimentation on a four-stroke engine and as Suezmax tankers normally employ a low-speed two-stroke, it can be speculated as being an MAN B&W ME-LGI type. These engines are already in service as ME-LGIP models running on LPG, which shares many characteristics with ammonia, so conversion should be a relatively simple matter. The alternative is a WinGD X-DF type but that company has been less public in announcements than MAN Energy Solutions.

In late 2019, Proman Stena Bulk, the joint venture between Proman and Stena Bulk, announced an order for two methanol fuel-ready 49,900dwt IMOIIMeMAX chemical/product tankers. A year later a third ship was added to the order. In January, it was reported that Guangzhou Shipyard International had cut steel for the first vessel. Since the first order was announced, the methanol-ready description has altered to methanol-fuelled and mention is made of the ships' MAN dual-fuel engines that will feature new water and fuel emulsion technology, which significantly reduces NOx emissions without the need for costly catalytic conversion technology.

While it is clear that opinion on future fuels is diverging, the one constant is that it is internal combustion engines are making the running. *NA*

Ballast water treatment

IMO and USCG approval for CompactClean ballast system

Danish ballast water management system (BWMS) provider DESMI Ocean Guard A/S has received approval from both the US Coast Guard and Danish Maritime Authority (DMA) for a new configuration of its CompactClean solution, the latter meaning it also has IMO (G8) approval.

The new arrangement, known as CompactClean Bulker, is designed for higher flow rates during deballasting, a particular challenge for bulk carriers. Dry cargo vessels often load cargoes twice as fast as they unload, making it particularly important to have a BWMS that reflects this.

Unlike many typical systems, which have been approved with just one maximum flow rate, the CompactClean Bulker is said to offer a tailor-made solution that can be configured with any combination of its approved filters and UV units. Since there is no need to filter the water during deballasting, a higher flow rate can be accommodated by selecting a larger UV unit.

Rasmus Folsø, CEO of DESMI Ocean Guard, cites the recent example of a bulker owner that selected a CompactClean BWMS with a filter with a maximum flow rate of 750m^3 and a UV unit with a flow rate of 1,500m^3 as evidence of the system's efficacy.

He says: "It may sound simple, but such solutions can make a world of difference for the customer, and therefore, we are ready to go the extra mile to ensure that this is fully approved."

Lubricants

Shell seals lubricants contract with Carnival Corp

Shell Marine has secured a multi-year contract to provide lubricants for Carnival Corporation's 89-strong fleet of cruise ships.

Under the terms of the deal, Carnival will also offset the CO_2 emissions of the marine lubricants through Shell's nature-based carbon credits scheme, by which Shell invests in projects which protect, transform or restore land. The company has stated its ambition to become a "net-zero" emissions energy business by 2050 or earlier.

Shell Marine's general manager, Joris van Brussel, says: "Through our marine lubricants and integrated service offering which includes technical and digital services, we're helping customers like Carnival optimise engine efficiency, thus reducing a ship's environmental impact."

Carnival Corporation has its own ambitions of reducing its CO_2 emissions by 40%, in alignment with IMO's 2030 targets. Other ongoing initiatives include equipping its vessels with advanced air quality systems and water treatment, and increasing the usage of shoreside power (cold ironing) while docked.

Batteries

Corvus launches containerised battery room solution

Canadian battery specialist Corvus Energy has launched a containerised solution for Battery-On-Board (BOB) applications named Corvus BOB.

The standardised, DNV GL-approved solution will be available in 10-foot and 20-foot ISO high-cube container sizes. Described by Corvus as a "complete energy storage system (ESS)", the Corvus BOB will come equipped with battery modules, a battery monitoring system (BMS), cooling, TR exhaust, and firefighting and detection system. A 'plug and play' approach will simplify the battery room's integration with the ship's onboard power management system. The first Corvus BOB solution will incorporate the Corvus Orca ESS, already widely used for merchant, cruise and offshore vessels.

Work on the container concept began in 2016, driven heavily by the demands of Corvus client Shell, which believes shipowners and operators will benefit from the flexibility of a modular battery system.

Bo Jardine, Shell global category manager, marine, explains: "The benefit of a containerised battery system is that you can add more containers if additional capacity is needed or move containers to another vessel in your fleet if charter contracts or operational requirements require it. It is easy to

The Corvus BOB

exchange the ESS when new technology is available and take the ESS off for a second life onshore."

Data analysis

Yxney Maritime becomes Inmarsat Fleet Data app provider

Yxney Maritime, a Norwegian company offering data-driven solutions for shipowners and energy companies, has joined the certified application providers for Inmarsat's Fleet Data service.

Fleet Data collects data from onboard sensors, pre-processing it and uploading to an Application Process Interface (API). Yxney, which has developed a software solution named Maress to help shipowners analyse fuel and emissions data, will use the Fleet Data API to provide clients with a simple and robust way to connect with live vessel data.

Gjord Simen Sanna, Yxney CEO, says: "Through the partnership with Inmarsat, we're excited to provide vessel owners and operators with a plug-and-play solution to feed actual asset data into the Maress software to make better strategic decisions on how to reduce emissions footprint."

Digital shipping

KVH: naval architects growing savvy to IoT

Building Internet of Things (IoT) into marine design has become a hot topic of late according to communication equipment specialist, KVH Industries. The company has been contacted by several naval architects to discuss ways of using connectivity to extend their relationship with a ship once it has been designed and launched.

As Sven Brooks, senior director of IoT business development for KVH, explains, ship designers are beginning to recognise the importance of digital integration: "Primarily because shipyards are asking for it. Shipowners are going back to the yard and saying they would like to see an 'IoT-ready ship' and shipyards are then returning to their designers saying they need an 'IoT-ready design'."

The company is engaging with these areas as part of its KVH Watch movement, ensuring that architects understand how data is being gathered, collected and shared on top of infrastructures required.KVH Watch is the company's solution for 'IoT Connectivity as a Service'. It provides 24/7 machine-to-cloud satellite connectivity for remote monitoring of onboard equipment. The platform also enables on-demand remote expert interventions performed through video, voice or text using KVH's global high-throughput satellite (HTS) network, which is being utilised by its newest partner, KILO Marine. Existing partners also include Kongsberg, ioCurrents and TMS Maritime Solutions.

Brooks stresses that while in traditional naval architecture hull structure, hydrodynamics, general and interior design are all taken into account, digital design also needs to be addressed. He compares the automation of modern vessels with buildings, noting that similar things are considered in both, such as air conditioning, water or piping systems.

"When you draw that parallel and see how buildings are designed, you find that digital design is starting to become a huge portion of it, and I think naval architects are starting to understand that."

Waste treatment

Wärtsilä to supply Carnival waste treatment solution

Wärtsilä has signed a framework agreement with Carnival Corporation to provide its advanced waste water and dry waste treatment systems for 32 vessels across the cruise operator's various brands.

The contract, signed in October 2020, covers provision of Wärtsilä's Membrane Bioreactor (MBR), for grey and black water treatment, and its dry waste handling system, designed to minimise greenhouse gas emissions. The MBR system exceeds IMO requirements for sewage discharge, including the special areas covered by paragraph 4.2 of MEPC 227 (64).

Arto Lehtinen, director at Wärtsilä's water and waste division, comments: "There is increased awareness within the cruise industry of environmental sustainability, and Wärtsilä is proud and ready to support this focus with the most advanced and compliant solutions. We continue to work with Carnival to enhance their goals for waste reduction, in line with their internal strategy."

The Wärtsilä equipment will be delivered and installed onboard the Carnival ships between 2020 and 2025. *NA*

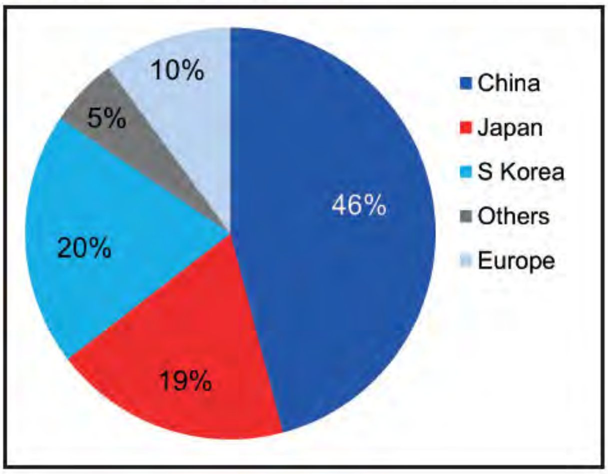
Wärtsilä's Membrane Bioreactor

Clarksons Research: Historical and Scheduled Deliveries Report

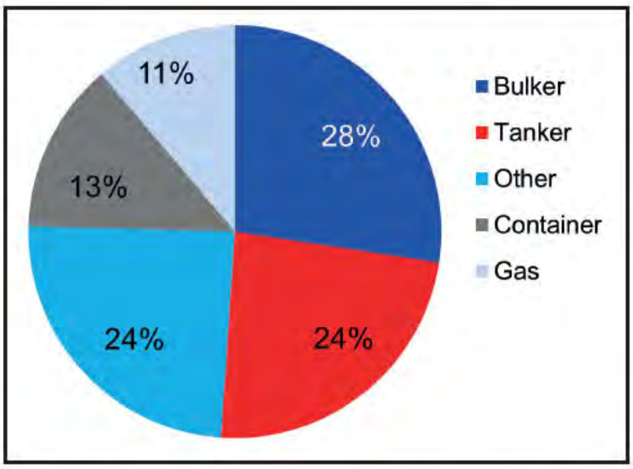
Data extract from World Fleet Register available at www.clarksons.net/wfr

Vessel Type	2009		2010		2011		2012		2013		2014		2015	
	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	33	20	30	24	35	27	27	22	21	9	14	10	9	11
Suezmax 125-200,000	23	22	26	11	26	18	30	15	23	4	4	4	7	3
Aframax 85-125,000	63	33	39	31	28	31	30	15	14	6	4	13	22	10
Panamax Tankers 55-85,000	26	12	15	16	19	10	9	6	7	5	3	1	2	1
Products 25-55,000	92	67	65	46	45	28	27	30	49	29	49	49	60	57
Products 10-25,000	6	5	7	7	8	6	13	6	9	4	1	8	4	0
Chem & Spec. 10-55,000	106	69	77	59	53	40	38	8	8	13	12	11	36	29
Tankers < 10,000	74	77	71	56	56	58	76	40	38	39	32	25	19	23
Capesize > 100,000	33	77	101	111	129	122	149	65	63	40	56	38	46	42
Panamax 80-100,000	27	21	60	61	81	97	140	94	101	68	62	35	57	41
Panamax 65-80,000	18	15	18	33	36	44	53	39	34	42	42	20	19	4
Handymax 40-65,000	84	100	168	166	199	198	228	146	147	119	98	102	144	121
Handysize 10-40,000	177	195	186	186	186	179	226	117	116	83	97	66	100	83
Combos > 10,000	0	0	3	2	3	0	0	0	0	0	0	0	0	0
LNG Carriers	22	17	15	12	5	10	1	2	4	13	14	19	16	16
LPG Carriers	25	18	18	18	16	14	13	8	22	16	14	14	25	40
Containers > 8,000 teu	21	14	29	33	48	30	51	28	51	33	59	42	58	62
Containers 3-8,000 teu	59	59	76	41	31	21	39	19	46	29	26	25	18	6
Containers < 3,000 teu	69	55	57	26	33	34	37	40	29	19	22	28	27	35
Offshore	11	19	20	25	26	20	29	10	11	19	32	30	25	13
Cruise Vessels	3	6	9	4	4	2	6	1	6	0	3	2	5	1
Passenger Ferries	11	7	10	13	11	10	11	8	6	6	12	8	13	8
Other	152	162	174	179	183	183	191	99	100	84	72	63	69	48
TOTAL	1,135	1,070	1,274	1,160	1,261	1,182	1,424	818	905	680	728	613	781	654

Orderbook by builder region (number of vessels)



Orderbook by sector (number of vessels)



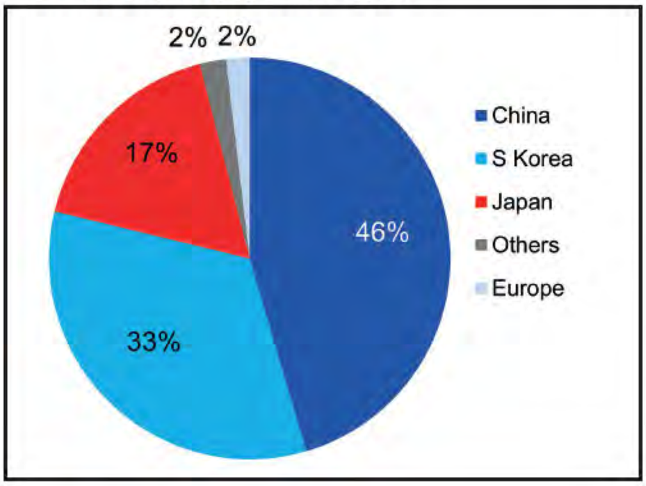
2016		2017		2018		2019		2020		Scheduled Orderbook		
1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	2021	2022	2023
23	24	29	21	21	18	39	29	22	15	35	36	8
8	19	35	22	25	7	23	3	11	19	28	31	2
31	22	36	28	26	24	41	12	12	5	62	30	11
7	11	10	11	7	6	6	7	6	5	7	3	0
60	42	39	25	27	22	50	46	43	29	94	27	1
3	2	6	6	10	8	5	9	5	4	9	1	0
43	38	38	31	45	41	34	28	32	24	54	28	2
23	16	25	36	45	43	27	29	26	20	57	10	0
64	39	55	20	30	21	31	49	64	48	82	35	4
71	40	75	27	39	25	69	64	96	45	127	42	4
1	2	6	1	2	2	1	4	3	0	1	2	0
124	94	125	54	58	33	56	77	93	59	123	75	0
85	46	69	31	47	44	52	40	38	34	96	25	1
0	0	0	0	0	0	1	2	0	2	3	0	0
15	18	20	12	32	23	22	20	16	21	74	33	27
49	33	45	17	26	9	16	13	20	14	50	35	7
37	26	34	36	47	23	27	23	13	22	61	31	23
2	0	2	5	7	3	6	1	1	5	6	3	4
39	27	35	42	50	38	46	55	42	53	127	44	1
25	19	18	24	25	13	9	9	5	3	46	22	11
8	2	7	3	8	4	12	10	6	8	28	36	19
6	16	20	10	11	18	16	16	11	13	59	18	6
50	60	50	54	49	47	56	53	38	49	210	61	6
774	**596**	**779**	**516**	**637**	**472**	**645**	**599**	**603**	**497**	**1,439**	**628**	**137**

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 2021

Orderbook (DWT) by builder region



Source:
Clarksons Research

Chinese research vessels: the past, the present and the future

After a blowout phase in the construction of China's scientific research ships comes to a close, industry experts and investors are contemplating what is on the table for the sector's future

Scientific research vessel *Tan Suo 1*

An upsurge in the development of Chinese research vessels is lasting longer than expected. In recent years, whether it be a comprehensive or specialised survey ship, new construction and modification projects have continued to emerge. Faced with this trend, shipping investors and developers are weighing in on how long the wave will last.

At the 2nd Marine Science Research Vessel Technology Summit held in late 2020, some industry insiders believed that this blowout phase of research ship projects will transition to a steady period, but that's not to say that development of this ship type will gradually go cold. On the contrary, in order to meet the strategic requirements for building China's maritime power, relevant equipment needs to be further improved upon in terms of quantity and quality. Whether it is the iterative upgrading of a single vessel or the optimised construction of a fleet or ship network, pace needs to be picked up.

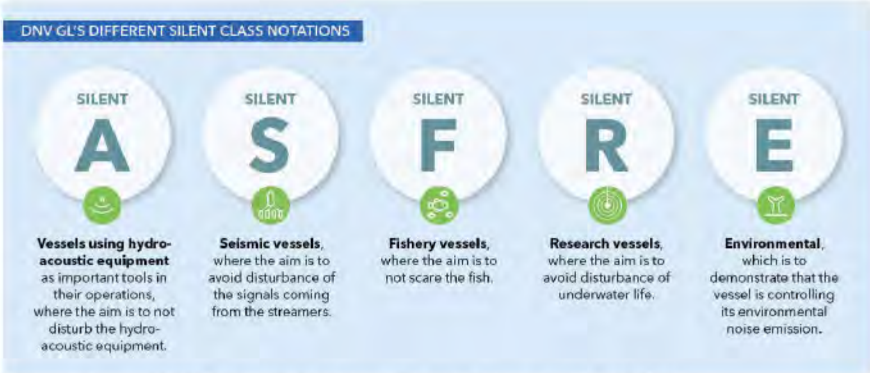
Exceeding expectations

During a relatively low period in the global shipping market, the performance of China's scientific research ships has surpassed the industry's expectations in terms of scale and level. As Wu Gang, researcher at China State Shipbuilding Corporation's (CSSC) 708th Research Institute, points out: "When comparing China's Dong Fang Hong ship series with international Tai Yang and Tan Suo series, our scientific research vessels have caught up with and exceeded international standards in terms of economy, manoeuvrability, underwater radiated noise, comprehensive investigation ability, etc."

Silent ships

Silence is one of the defining characteristics of China's contemporary research vessels. A ship's engine, ventilation and piping systems, scientific equipment and more bring about vibration and noise, not only causing interference on underwater organisms and onboard personnel, but also directly effecting the reliability of scientific data. Therefore, vibration and noise control is vital in the design and construction of such vessels.

In March 2017, Xiamen University's 3,000dwt scientific research vessel, *Jia Geng*, was delivered. It became China's first ship to obtain DNV GL's SILENT A and SILENT S notations, highlighting the country's development of silent vessels. In May 2019, the Ocean University of China's 5,000dwt research vessel *Dong Fang Hong 3* was delivered, the first ship domestically and fourth ship internationally to obtain DNV GL's SILENT-R certificate, the strictest level of underwater radiated noise requirements in the classification society's SILENT notation. At the time, *Dong Fang Hong 3* was also the vessel with the largest tonnage of those which attained the certificate globally.



A breakdown of DNV GL's SILENT class notations Image credit: DNV GL

Elsewhere, the Chinese Academy of Science's 3,000dwt geophysical research and survey vessel, *Experiment 6*, is the first in China to adopt hybrid cooling D-pod propulsion technology and there are plans for it to gain DNV GL's SILENT A and SILENT S certifications (see *TNA* September 2020). Whereas Sun Yat-Sen University's 5,000dwt oceanographic research and training vessel, *Sun Yat-Sen University*, is the nation's first domestic ship with an L-type fully rotating low-noise propeller, permanent magnetic bow thrusters, DC busbar and energy storage battery technology and full speed active fin stabilisers.

The above series of innovations enables the ship to increase its test conditions to ultra-quiet mode and its dynamic positioning operations can meet China Classification Society's COMF (N2 / V2) comfort level. It is anticipated that it will become the country's first domestic ship of its type to have silent dynamic positioning capabilities and obtain a DNV GL SILENT-F certificate.

DNV GL, which took the lead in developing ship noise notations, has participated in the rapid development of Chinese research vessels in recent years. "My colleagues in Norway are very surprised at the emphasis on silent research ships in China. No matter if it's the design capability of an institute, the construction technique of a shipyard, or project-based organisation, all parties in China attach great importance to it," says Liu Xiaofeng, head of DNV GL China Technology Centre's maritime advisory department.

"Looking at the comparison between underwater noise control in domestic and international vessels, China's silent research ships have already reached an internationally advanced standard, which is not easy," he adds.

Fields of improvement

The construction and delivery of several major projects has enabled development in specialist areas of China's oceanographic research.

During 2017, the 'three musketeers' of China's geological survey ships were delivered. *Haiyang Dizhi-8* is the country's first high-precision short-sea geographic survey ship, capable of creating high-resolution three-dimensional images of the seabed's geological structure, which places the country in a commanding position in the field of international marine exploration. *Haiyang Dizhi-9* is China's only vessel able to simultaneously carry out specialised seismic, geological and geophysical work, and *Haiyang Dizhi-10* is the first geological survey ship built independently by China with a high-precision drilling function. Delivery of these three vessels marks the initial completion of a three-dimensional technology system for deep-sea exploration in China.

Two 3,000dwt fishery research vessels, *Lanhai 101* and *Lanhai 201* of the Chinese Academy of Fishery Sciences, were delivered in 2019. They became the leading force in the expansion of China's scientific investigation of marine fisheries and play an important role in carrying out research work, such as assessing the development of fishery resources, monitoring and evaluating the ecological environment of fisheries, applying satellite remote sensing, as well as testing fishing gear and methods.

That same year, China also delivered its first independently built icebreaking research vessel, *Xue Long 2*. At present, the ship has already proven its ice breaking and manoeuvrability capabilities in both North and South polar regions, advancing the country's overall capacity for on-site polar investigation support.

In addition to the above-mentioned ships funded by government departments, some social powers have also devoted themselves to marine scientific research, creating several unique vessels. Investments made by private enterprises include *Shen Lan*, an Antarctic krill fishing and processing vessel delivered in 2020, *Shen Kuo*, a 2,200dwt small waterplane area twin hull (SWATH) research ship delivered in 2018, as well as China's 10,000m-class manned submersible, *Rainbow Fish*, and its mother ship, *Zhang Jian*, both delivered in 2016.

Meeting new demands

In October 2017, the 1st Marine Science Research Vessel Technology Summit was held in Shanghai, with representatives from all major parties involved in the investment and development of domestic scientific research vessels.

Wu Gang, who was in attendance, believed that the blowout period of these ships was coming to a close and newly built scientific research vessels could already fundamentally meet the demands of the country. But during the following three years, he witnessed the demand for these ships at all industry levels and gained a deeper understanding of what is needed: "The pace of constructing China's maritime power is still accelerating, which brings with it new requirements for research equipment. In fact, maritime colleagues should have extensive experience. That is to say that our country's current marine scientific research ability is not enough to provide sufficient support for the national maritime strategy.

"Our equipment, technology, team and management mechanisms need an in-depth reformation and optimisation, equally the quality and quantity of equipment needs to be greatly improved, so as to support the further perfection and development of China's marine survey system," he adds.

According to industry experts, China's research vessels have gone through a period of rapid progression, filling in many loopholes and weaknesses in the field of equipment. However, these ships still have a long way to go, whether from the scale of the gap between China and the United States, the European Union and other major economies in the world, or from the future demand of China's marine resources, exploration and development.

A plan of action

The consensus reached by the industry is to strengthen the design of marine scientific research equipment nationally, but how can this be achieved?

First, enhancing the overall planning of newbuilds and promoting the standardisation of different ship types. Wu Gang believes that after the swarm of construction subsides and China's research ship market transitions to a steady period, the country needs to draw up a blueprint for the development of the next generation of research vessels. Within this, the standardisation of ship types is key.

"Building a ship still takes too long. At present, it takes 5-10 years for the latest scientific research ship in China to progress from planning to project approval to delivery. In that period, the advanced technology and targets may become out of date by the time of delivery," Wu comments. He adds that if the standardisation of this ship type is realised, the entire construction period can be expected to reduce to 2-3 years, which is also instrumental in the incremental updating of technical equipment.

Second, bringing into play synergy with existing ships and promoting the development of China's scientific research fleet. Establishing this fleet is not a new topic. The former State Oceanic Administration previously set up a 'China Marine Research Fleet', the National Natural Science Foundation of China (NSFC) has a shared voyage plan, and the Chinese Academy of Sciences possesses its own scientific research fleet. However, compared with the United States' University-National Oceanic Laboratory System (UNOLS) and the US National Oceanic and Atmospheric Administration (NOAAs) fleets, the above mechanisms are still not perfect and have inadequate management and cross departmental allocation of resources. In addition, China lacks fleet alliance across industries and units.

Sun Yat-Sen University's executive vice president, Sun Dongbai, says that China can learn from international experience and set up a 'University Marine Science Research Alliance' and 'National Marine Science Research Alliance'. He adds that in China, where the task of scientific research is heavy and the number of corresponding ships is small, significant goals and large teams should be established to collectively build an industry platform.

Third, promoting the localisation of key marine survey technology and equipment. As it stands, a number of ships and scientific devices installed on China's advanced research ships, such as azimuth thrusters, specialised winches, high-precision acoustic equipment, sensors and so on, are highly dependent upon imports. If this situation does not change, it will become the biggest pain point restricting the growth of the country's research equipment.

It has been reported that, at present, China has already begun independent development of fully rotating thrusters (azimuth thrusters), LARS systems, scientific research winches and other equipment, whereas technological breakthroughs in special acoustic detection equipment, sensors and other systems are reliant upon in-depth collaboration inside and outside of the industry. Further, the localisation of such high-end ships and research apparatus requires top-level planning and support. *NA*

Chinese scientific research vessel *Xiang Yang Hong 1*

CMA CGM's gas giant

As a special preview of our forthcoming *Significant Ships of 2020*, *The Naval Architect* takes a look at arguably the most high-profile vessel delivered by a Chinese yard last year: *CMA CGM Jacques Saadé*

CMA CGM Jacques Saadé's colourful livery proclaims its gas propulsion. Image: CMA CGM

Perhaps the biggest talking point for container ships since Maersk's 'Triple E' design was unveiled in 2011, *CMA CGM Jacques Saadé* may eventually be eclipsed in size but will always be able to claim the title of the world's first LNG-powered ultra large container ship (ULCS). So it should come as no surprise that it's one of the vessels included in RINA's *Significant Ships of 2020* publication, which will be published later this month.

French operator CMA CGM originally signed the contract for the ship and its eight sisters with China State Shipbuilding Corporation (CSSC) in September 2017, with the work being split across subsidiaries Hudong-Zhonghua Shipbuilding (Group) Co., Ltd. (five vessels) and Shanghai Jiangnan-Changxing Shipbuilding (four vessels). Delivery of the series was supposed to commence in November 2019, but neither yard had great experience in building vessels with two-stroke LNG propulsion systems and it seems likely this contributed to delays, which were then further exacerbated by the Covid-19 pandemic.

CMA CGM Jacques Saadé was finally delivered by Hudong-Zhonghua on 22 September 2020, with Shanghai Jiangnan-Changxing delivering the next vessel, *CMA CGM Champs Elysees*, a month later. To date, four ships have entered service. The series was designed by the Marine Design and Research Institute of China (MARIC).

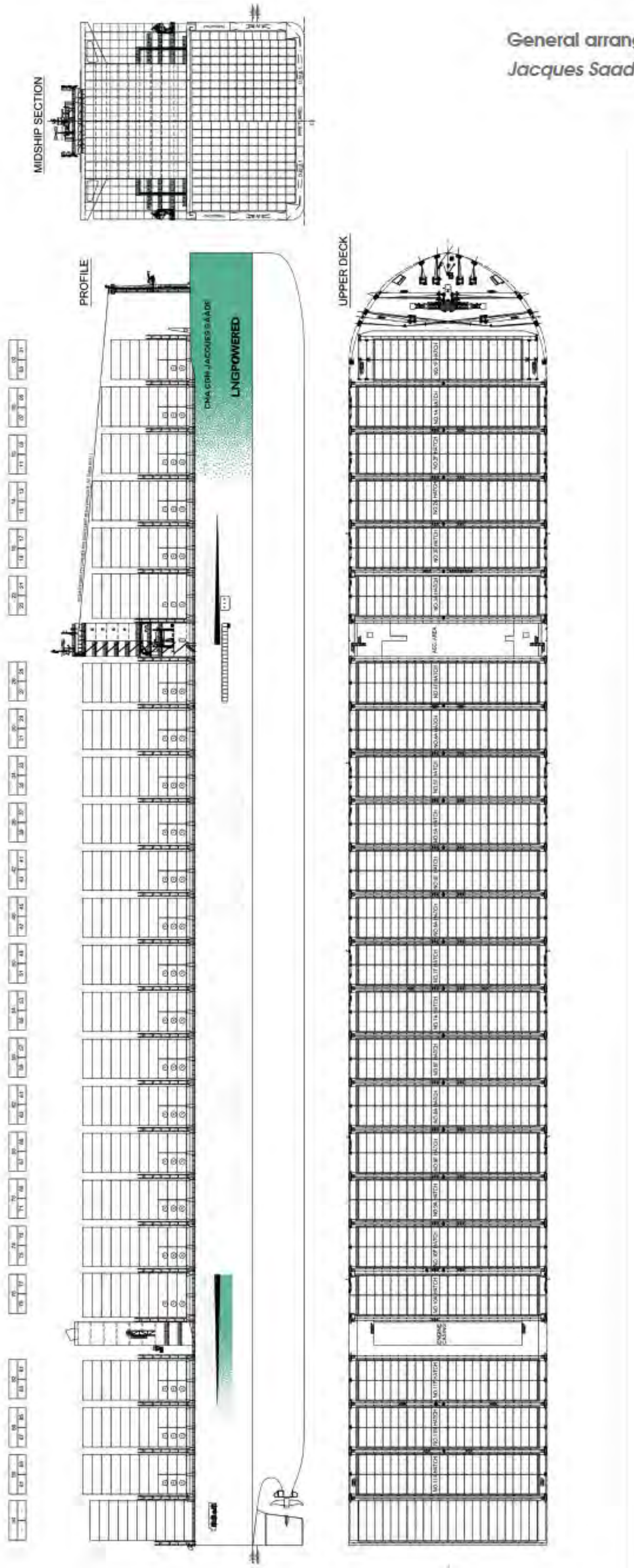
With its length a shade under 400m, beam of 61.3m and moulded depth of 33.5m, *CMA CGM Jacques Saadé* has a total capacity of 23,112TEU of which 13,328TEU are on deck and 9,784TEU under deck. CMA CGM boasts that the vessel's "outstanding design" means that it is possible to stack containers of over 10tonnes in a 10-high stack. During the ship's maiden call at Singapore in October 2020, a world record 20,723 "full containers" were loaded in a process consisting of some 4,000 separate crane load-ing and unloading movements (before commencing a 13-call journey to Europe). However, as with all container ships, the total capacity is significantly reduced when using a homogenous loading of 14tonnes per TEU. Under this measure, capacity falls to 14,180TEU at scantling draught of 16m. There are 2,200 electric points for reefer boxes. Cargo loading ability has been optimised using specifically designed lashing bridges and a loose lashing system.

But, of course, it's the choice of LNG as fuel that has been the main topic of conversation for *CMA CGM Jacques Saadé* ever since its first announcement. While other boxship operators, such as Hapag-Lloyd, have since opted for LNG, the majority of orders for similar sized newbuildings still favour HFO and scrubbers as doubts persist about gas. By contrast, CMA CGM has strengthened its commitment and expects to have 26 dual-fuelled containerships by 2022, including the series of six 14,806TEU ships currently being built at the Hyundai Samho shipyard in South Korea.

TECHNICAL PARTICULARS	
CMA CGM Jacques Saadé	
Vessel type:	Container ship
Length (oa):	399.9m
Breadth moulded:	61.3m
Depth, to main deck:	33.5m
Deadweight, design:	189,260.5dwt
TEU capacity:	23,112
Complement:	9 officers, 20 crew (max)

CMA CGM Jacques Saadé is powered by a single WinGD 12X92DF dual-fuel engine, rated at 63,840kW, which utilises WinGD's successful X-DF low-pressure concept for propulsion. Weighing in at 2,140tonnes, in January, following tests carried out by builder CSSC-MES Diesel Co, it was officially declared by Guinness World Records to be the most powerful marine internal combustion engine (Otto cycle) commercially available. The ship could also run on VLSFO or MDO, but the owner has specified a large 18,762m^3 GTT Mark III tank for LNG, allowing the ship to complete a Far East – Europe round trip on one bunkering. By contrast, the HFO tank would only provide for 10 or 11 days of sailing. It is linked to a 10.1m diameter propeller rotating at 80rpm, granting a service speed of 21.97knots at 90% MCR.

Even the vessel's inaugural bunkering represented a landmark, a 16-hour operation at the Port of Rotterdam in November 2020 involving another of last year's newbuilds, *Gas Agility*, itself the world's largest LNG bunkering ship and specially built to service the anticipated next generation of ULCS's. *NA*



General arrangement of *CMA CGM Jacques Saadé*

Indoor/outdoor spaces pose operational challenges on cruise ships

Kari Reinikainen speaks to HVAC providers about the increasingly sophisticated ventilation solutions they are being called upon to develop

Passengers on cruise ships like to wander in and out much as they would on dry land, i.e. without having to negotiate doors that open and shut as they pass. But creating such indoor/outdoor spaces onboard ships is demanding given the particular requirements of heating, ventilation and air conditioning (HVAC).

Humidity is a major source of those challenges e.g. creating cabins that feature doors which can be opened and thus remove an entire wall to the balcony, says Uwe Jakubowsky, engineering manager at Aerius, the German HVAC specialist.

If the temperature inside the cabin is kept low and the air outside hot and humid, as is often the case when the ship operates in warm climates, condensation starts to build within the space. Over pressurising the cabin offers a way to tackle the problem, he tells *The Naval Architect*.

Aerius supplies HVAC systems to the Edge class ships of Celebrity Cruises, which are being built at Chantiers de l'Atlantique in France. These vessels feature Infinite Veranda cabins, in which the wall to the balcony slides to the sides and transforms one side of the cabin into outdoor space.

On the other hand, a glass panel can be raised to turn the balcony into inside space, with a floor to ceiling window facing the sea. Similar cabins are found on other recent newbuildings, such as P&O Cruises' *Iona*, where they are called Conservatory Mini Suites.

Buffet areas are another location where such an arrangement would be quite welcome. In most cases, the main pool area lies in front of the restaurant and an open deck aft of it. People want to sit outside, so there is a heavy flow in and out. Automatic sliding doors are used to separate the indoor area from outdoor ones, and making these indoor/outdoor areas seamless poses its own challenges.

"In lido buffet zones, you need to use air locks, over pressurising the inside areas does not work," Jakubowsky says. The ship's forward motion creates a wind and if doors are open to a deck aft of the buffet, the airflow through the space becomes so strong that it cannot be sealed off with just over pressurising the area, he explains.

The 'Infinite Veranda' found on cabins in Celebrity Cruises' Edge class series

Humidity and safety

Joep Hopman, CEO of the Dutch HVAC system supplier Heinen & Hopman, comments that air can only be blown in by the HVAC system in indoor/outdoor areas, otherwise humidity and condensation becomes a problem. This leads to a loss of system efficiency in these areas, which he says amounts to the region of 25-30%.

Two questions have hampered efforts to better merge indoor and outdoor areas onboard cruise ships, says Vesa Marttinen, senior advisor at the Finnish consulting company MarineCycles. "The first one is fire safety: what category spaces are we talking about in SOLAS terms. The second one relates to air conditioning. Removing humidity from the air in areas inside has been a problem," he tells *The Naval Architect*.

A Conservatory Mini Suite onboard P&O's *Iona*

Cruise ships operate in various climate conditions, with significant fluctuations in outside air temperature, yet the experience for passengers should always remain a pleasant one. 'Air curtains' produced by the air conditioning system onboard have been developed to tackle these problems as well as indoor humidity issues, and the results have improved over the years.

However, when considering this method, operating costs from increased use of air conditioning capacity and capital expenditure linked to the increased capacity required from the air conditioning plant enter the picture as well.

"In recent times, there has been a lot of effort in the development of HVAC to allow air circulation without cooling it. Ultimately, the question is about whether passengers are able and willing to pay for any new experience onboard," Marttinen says.

In the cruise industry, innovations onboard ships are often based on consumer trends that are taking place ashore. As the demand for a new innovation concept grows, cruise lines will need to introduce ones onboard, he concludes.

Esko Nousiainen, who heads the cruise business area at the finnish HVAC specialist Koja, comments that commercial reasons drive the industry to introduce new features, including cabins that can be converted into indoor/outdoor areas. "There are quite a few new ships on order and many of them are due to enter service in the near future. There is a need for special features to make vessels stand out," he adds.

However, given the fact that features such as these types of cabins involve both higher operating expenses as a result of increased energy consumption of the HVAC system and a rise in capital expenditure as well, they will be introduced in limited numbers and at higher end cabin categories. *NA*

Seafarers and ships: enhancing onboard cabin comfort with connectivity

With the shipping sector being impacted by Covid-19, manufacturers and operators must review the onboard conditions of crew more than ever, says Tanguy Morel, co-founder and CEO of Moment

As the world started to implement national lockdowns in 2020 due to the pandemic, the role of the merchant shipping industry became even more essential. With borders closed and most people stuck at home, we increasingly relied on the industry for the delivery of consumer goods, food and medical supplies. However, the pandemic also highlighted the situation of seafarers who were feeling stressed, anxious and exhausted. Indeed, the Seafarers Happiness Index report, published in May, revealed clear concerns about current safety and welfare provision, with crew urgently calling for improved connectivity between shore and sea. Often considered as the forgotten ones, the 1.6 million seafarers employed around the world play a crucial role in shipping companies' day-to-day operations, in charge of difficult tasks such as vessel maintenance, management of goods and their unloading. As a result, crew turnover rate can be high while recruitment remains difficult.

The industry has started evaluating technologically advanced products and looking at future projects that will modernise navigation, such as remotely operated autonomous ships. Yet, while interesting, this kind of innovation is still a work in progress and will likely take years to develop. In the meantime, shipping companies must increase their productivity to respond to growing global needs; seafarers play a crucial role in this strategy. Therefore, recruitment and retainment policies are key and must take into account the IMO's regulations. According to said rules, regardless of their nationality, seafarers can stay on the same vessel for up to 11 months. Exhausted crew members can cause potential accidents and spending months away from the mainland can have social and moral repercussions on them.

The attractiveness of these jobs is essential for the sustainability of a sector that has undergone profound changes for the past 30 years. Increased work, commercial constraints, managerial requirements and employment conditions of seafarers have had an impact on companies' organisation. In order to keep the crew spirits high, even when they need to work 24/7, ensuring their wellbeing must be at the heart of the strategy, especially since the Covid crisis has restricted sailors from going home because of quarantines or border closures. In this sensitive context, the accommodation of crew is a priority and should be reviewed to contribute to their well-being onboard ships.

The provision of onboard connectivity is playing an increasingly important role in crew comfort and, ultimately, retention

Modes of transportation are changing with technology. While aviation has already embraced this to provide advanced services and an enhanced passenger experience while optimising flight operations, the maritime industry has been evaluating how to develop onboard services. Concerning the merchant shipping sector, digitalisation can bring real added value by improving the standard of living.

Digital platforms provide an answer to this issue as they enhance onboard living by enabling seafarers to access entertainment services, high-quality content, WiFi or infotainment. Connectivity also allows communication with family, as well as access to health and education remote services. Shipbuilders and operators can lean on these solutions to provide innovative services onboard, accessible from the crew accommodation. Flexible and performant, digital platforms have the advantage of not representing heavy installations as they can function in an offline environment. Based on wireless systems, platforms generate a local Wi-Fi network accessible to the apparatus on the ship. Available from personal electronic devices, the digital portal creates a rich experience onboard.

Beyond entertainment, digital solutions can also enable Internet of Things (IoT) technology, an increasingly interesting opportunity for the maritime industry which enables advanced services, higher level of comfort, and operational improvements. Powerful service and automation tools can also be developed to extend crew capacities.

The deployment of a digital portal can contribute to upgrading onboard accommodation and improving the lives of seafarers. For ship operators, that means a more engaged and committed crew, as well as a higher retention rate. The current pandemic has highlighted how important the industry is and how its role has been acknowledged as essential to keep global commerce running. Innovation will be key to accelerate the industry's development as it seeks to respond to the global trade demands and crew retention will be one of the pillars to its success. *NA*

https://moment.tech

Is lifeboat accessibility taken seriously?

SOLAS says lifeboats should be located close to accommodation spaces, but a growing number of designs are opting for free-release lifeboats at the stern

Lifeboat and liferaft provision has been at the heart of the Safety of Life at Sea (SOLAS) convention ever since the first treaty was signed in 1914, in the aftermath of *Titanic*. With regard to where these craft should be situated, the current rules state:

1. "[They] shall be stowed as close to accommodation and service spaces as possible"
2. "Muster and embarkation stations shall be readily accessible from the accommodation and work areas."
3. "Each survival craft shall be stowed, as far as practicable, in a secure and sheltered position and protected from damage by fire and explosion."

Such wording intentionally allows for some latitude in interpretation, but is there a danger that modern ship designs could be taking that license too far?

That's the opinion of Jan Babicz, a naval architect, surveyor, former chief designer of Gdansk Shipyard and author of *Ship Design in Practice* (see *TNA* March 2020), who has recently been highlighting some of the more egregious and potentially unsafe examples of lifeboat positioning. Among these are two new multipurpose (MPP) DP2 B-type vessels currently being built for Spliethoff at Mawei Shipyard, China, the design for which has the free-fall lifeboat located extreme aft aboard ship with the superstructure located fore (see Fig. 1).

Lifeboat arrangements of this nature are not uncommon particularly where free-fall lifeboats are involved. In a similar case, Wagenborg's EasyMax MPP tweendecker series (starting with the 2017-delivered *Egbert Wagenborg*) requires crew located in the superstructure to travel the length of the vessel via a corridor under the deck to reach the lifeboat.

Why is this allowed? Although lifeboats should be stored 'as close as possible' to the ship's accommodation, there is also a mandate under SOLAS III/31.1.2.1 that lifeboats can only be launched from the vessel's stern. Moreover, at the flag state's discretion, ships equipped with free-fall lifeboats may also be excluded from the SOLAS requirement for merchant vessels to have 200% lifeboat capacity. In other words, there is no need to supplement lifeboat provision with additional conventional davit lifeboats on the port and starboard.

Neither Conoship, naval architects for the under-construction Spliethoff vessels, nor Lloyd's Register, the appointed classification society, were available for comment when approached by *TNA*. However, one source explained that a determining factor in such decisions is SOLAS III/31.1.5, which states:

"All survival craft required to provide for abandonment by the total number of persons on board shall be capable of being launched with their full complement of persons and equipment within a period of 10 minutes from the time the abandon ship signal is given."

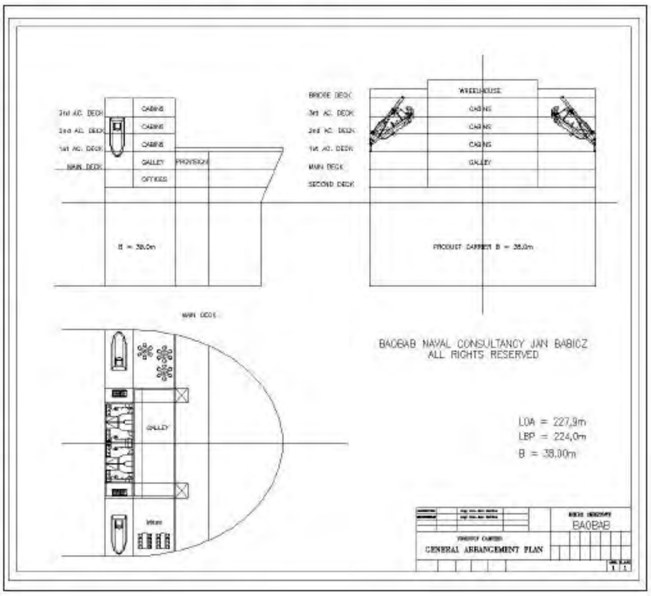
Therefore, one has to assume that, in the aforementioned examples, the classification societies are satisfied that the vessels could be completely evacuated in 10 minutes. In mitigation, it should also be noted that since the engines are located aft, officers and crew working in the engine room would be expected to reach the lifeboats in a much quicker time (although the bridge is clearly quite another matter).

Babicz tells *TNA* that he has inquired with a number of classification societies and regulators with little success. He explains: "I received three answers: from DNV GL, Russian Register and IMO. All of them defended the solution of free-release aft with accommodation foreship. DNV GL sees this as modern design."

Concept illustration for Spliethoff's DP2 B-type. Source: Spliethoff

He believes having a free-release lifeboat with accommodation fore is simply poor design that ignores crew safety. Furthermore, he doesn't think there is any technical reason why a free-release lifeboat couldn't be situated behind the superstructure (Fig. 2) or even at the front wall.

"In my opinion 'as far as possible' means that designers shall check all reasonable solutions to place lifeboats near crew accommodation. Their explanations I treat as an inadmissible compromise," he concludes. *NA*



Babicz thinks a free-release lifeboat could be stored behind the superstructure. Source: Jan Babicz

Saving lives through predictive modelling and anonymous data sharing

A non-profit data sharing organisation partnering with some of the world's leading shipping companies is helping the maritime industry anticipate the risks of high impact, low frequency incidents

The safety of seafarers has always been important to those of us who work in the industry, but the way we achieve it is changing. Predictive modelling is enabling more and more shipping companies to sail our seas safely. Every single day, incidents are being avoided and risks are being eliminated, thanks to anonymous data sharing and the use of sophisticated data analysis and predictive modelling.

Manit Chander

What is predictive modelling?

Every maritime voyage generates mountains of valuable data. This information is kept in many different formats and spread across databases and departments. Once this is collated, it is run through a predictive model to highlight real threats to seafarers. Predictive modelling works by combining the day-to-day experiences of seafarers – the 'weak signals' – with statistical analysis to see where small issues are likely to lead to catastrophic incidents. This modelling allows shipping managers to act much earlier and make small adjustments with a big impact.

Let's look at some real examples of predictive modelling in action. It has only been used in shipping for the past few years, but it has been making its mark on other industries around the world for decades. After the Ladbroke Grove rail crash in 1999, the industry formed the Rail Safety Standards Board (RSSB) to implement effective data sharing. The incident was caused by issues with signal visibility, which had been flagged numerous times but had not been addressed. The rail sector saw the need to create a central safety database to prevent future accidents.

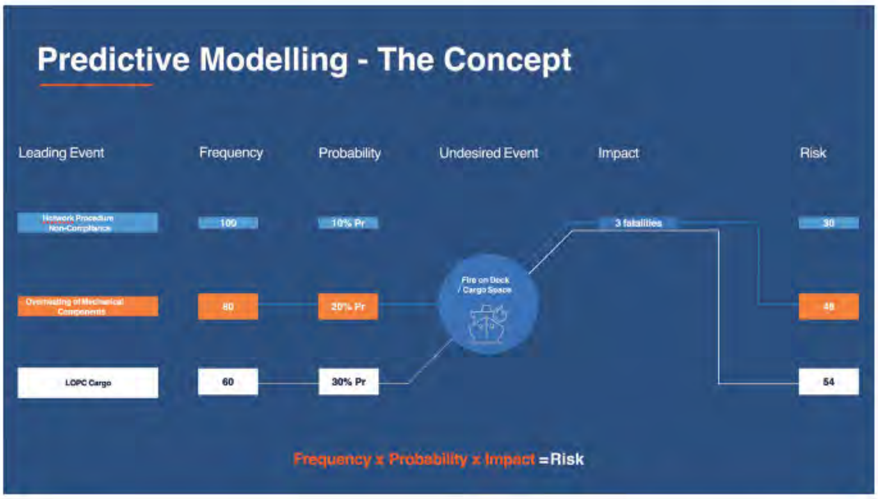
The RSSB collects data from every rail company in the UK and uses it to achieve safer practice across the industry. The organisation pinpoints the issues causing serious incidents and equips companies with the resources they need to reduce risks. As a result, accident rates have dropped significantly.

So, who provides the data?

Over 50 of the world's leading shipping companies anonymously share their data with HiLo in return for in-depth risk analysis. Some of the biggest names in the industry are committed to making our seas safer for everyone by providing their full internal safety data, including incident logs, audit reports and unscheduled work orders. This system is automatic, with no need for classification or standardisation, so HiLo receives every piece of safety data collected from over 4,000 ships.

Predictive modelling is used to assess data and calculate risks, enabling shipping companies to take action and limit danger to lives, the environment and their bottom lines. The more businesses who offer their data, the greater the benefit for the industry. Anonymous data sharing allows companies to learn from one another, turning everyday data into invaluable insights that can save lives.

In return, HiLo Risk Management delivers tailored reports to shipping companies, pointing out potential risks to their fleets. To give an example, based on the risk and size of its fleet,



HiLo predicted for one company that 15 individual fires would occur, which were likely to be a result of various different leading events. Subsequently, the company ran a safety campaign to manage the risks highlighted by HiLo, and fires were reduced from 15 to just two. In other words, because the company acted on the leading events identified, they stopped the weak signals from becoming fires.

What makes HiLo different?

With 20 times more data than the leading incident databases, HiLo Maritime Risk Management are a not-for-profit organisation dedicated to improving the safety of those who work at sea.

HiLo was founded in 2016 as a Joint Industry Project to answer the question 'is there anything we can do to predict and prevent shipping accidents?' These high impact, low frequency (hence HiLo) events are notoriously difficult to predict and are responsible for the deaths of thousands of seafarers. HiLo revolutionised risk analysis, using never before exploited data and a first-of-its-kind maritime statistical model to empower shipping companies to save the lives of their crew.

Because HiLo are non-regulatory, maritime companies can anonymously share their data without the threat of penalisation for mistakes. HiLo's secure portal gives businesses the chance to learn from near misses and incidents in the industry without risking their own confidential data. In the last four years alone, the team have analysed risks for approximately 4,800 ships and 150,000 events.

How HiLo save lives at sea

HiLo's CEO, Manit Chander, has been with the company since the very beginning. Chander spent almost 20 years working at sea and has dedicated his career to the safety of seafarers. As HiLo are independent, they are free to focus exclusively on what's always been their mission – using predictive modelling and data sharing to reduce the risks for seafarers.

HiLo Maritime Risk Management is saving lives in the shipping industry by changing the way companies understand and address risk. HiLo translates near miss, accident and incident data from its customers into a comprehensive risk profile for each company and the HiLo fleet as a whole. Armed with this information, companies using HiLo analysis can stop catastrophes in their tracks.

HiLo has also launched CUPID [Community Powered Ideas Dashboard], a subscriber forum for mariners to share tried and tested solutions to the highest risks in the industry. By connecting the industry with high quality safety information, HiLo has empowered a community of people passionate about saving the lives of seafarers and provides them with the resources to do so. This is a unique innovation which builds on Predictive Modelling, using big data and valuable insights from experienced mariners who have faced near misses, incidents or accidents in shipping. *NA*

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A legacy of saving lives at sea

Whenever the history of liferafts is mentioned, few companies can claim a longer heritage or a stronger legacy than Survitec

Yet, Survitec's latest developments in ship evacuation technology are a far cry from the first experiments of inflatable liferafts carried out in 1919 by Reginald Foster Dagnall on Wisley lake. Dagnall explored the potential of rubberised cloth as a flotation material and, a year later, gave his initials to the company he founded in 1920 to develop his ideas: RFD.

That business later went on to become Survitec as it's known today. This year marks its centenary, a period during which many other legacy companies have added their energy and expertise to give Survitec a vital, broader maritime safety role as requirements and technologies have evolved.

Dagnall did not initially focus on the maritime market. His experience came from making observation balloons so, with the Great War and the part played in it by early aircraft as his inspiration, his initial work led to the production of flotation devices for downed aircraft.

He developed a lightweight inflatable ring to prevent a ditched plane from sinking, allowing the craft to be recovered. Dagnall soon realised that, by adding a floor to the ring, it was possible to save the aircraft's occupants. This led, in 1928, to an inflatable boat – which would later be known as the liferaft we know today. And in the following year, flotation bags were supplied for planes launching from aircraft carriers and long-range aircraft making the journey from the UK to Africa.

In 1930, collapsible dinghies were displayed at an aircraft exhibition, marking the start of liferaft development, and in 1932, RFD patented an automatic inflation system. The next year, five trials were made using automatically inflated dinghies in Portsmouth in conjunction with the aircraft carrier HMS *Ark Royal*.

British engineer Reginald Foster Dagnall founded RFD, the company which would become Survitec

Expanding portfolio

But it was 1950 before RFD developed a full range of aviation and marine liferafts and there was particularly high demand for those with canopies. Four years later, these were approved by the UK's Ministry of Transport for use on trawlers and small merchant vessels sailing under British rules in British waters.

Their use spread and in 1955, navies from Holland, Denmark, Belgium, Canada, Australia, New Zealand and South Africa all carried RFD liferafts.

Afterwards, developments were brought about quickly. In 1956, the carriage of inflatables became mandatory for all UK fishing craft and in 1957, RFD introduced a 25/26-person liferaft that was lighter and smaller than its predecessors.

Then, in 1958, came an important breakthrough, when RFD introduced its 20-person MC-type liferaft. This could be lowered fully laden from a ship with an 18m freeboard by a single-arm davit.

Most importantly it could be released automatically. This overcame one of the problems with liferafts: passengers usually had to board them by climbing down ladders or jumping from height. Not only did this new design remove that difficulty but it also provided a means by which it could be recovered, complete with survivors, by a rescuing vessel.

An early advert for RFD's 'liferaft' concept

Among the significant products in Survitec's range that date back to its earlier years is Babycot, which was developed by Beaufort Air-Sea Equipment, another Survitec company established more than a century ago. Beaufort and RFD merged in 2003 to become RFD Beaufort, which is now a subsidiary of Survitec.

That product – now in its Mk IV version – remains unique in providing protection for infants and is widely supplied to the aviation industry.

Since the 1970s, as cruise ships have steadily grown until now, with the largest accommodating passengers and crew totalling nearly 9,000, liferaft capacity and their operation have been crucial factors in both that industry's development and Survitec's research.

Recognition of liferafts' importance to shipping safety was sealed when, in 1965, it became mandatory under SOLAS for ships to carry inflatable liferafts. RFD was the first manufacturer to gain approval under the new requirements, confirming its craft to be both safe and reliable. That reputation was further cemented in 1976, when the company produced the world's first welded liferaft.

Marine Evacuation System

Just three years later, it launched the world's first marine evacuation system (MES), introducing the concept that survivors could leave a ship rapidly, initially down a slide directly into a landing liferaft. Later developments introduced a vertical chute system to offer vessel operators a choice.

Irrespective of whether descent is by slide or chute, an MES saves space and speeds up the evacuation time enormously compared with previous boarding systems – vital in an emergency. They also made it possible to abandon ship without getting wet feet – a feature termed 'dry-shod' evacuation.

Survitec's present-day Surviva liferaft

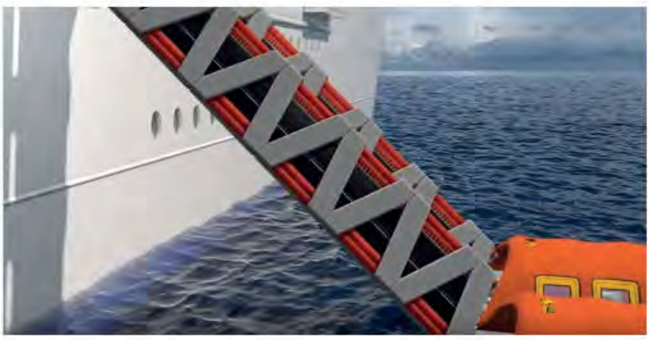
That MES was the first generation of RFD's Marin-Ark system, which is still available and consists of four large enclosed liferafts offering a combined capacity of 430 people. A significant design feature is that the liferafts are fully reversible, so there is no risk of them launching upside down. Further over-capacity liferafts can be added to boost capacity.

A second-generation system, Marin-Ark II, can be expanded to hold up to 860 people. It uses a dual spiral slide that speeds up evacuation and incorporates a feature that allows crew to ascend if necessary.

Another significant development is Survitec's recently rebranded RaftXChange liferaft rental service, introduced following a SOLAS amendment that came into force in 2008. The regulation allows extended servicing intervals of liferafts for some ship types, taking the normal 12-month interval and increasing it to 30 months.

Under the ruling, the liferafts have to be maintained within their containers at the correct ambient conditions. The solution Survitec developed was to hermetically seal the liferafts in watertight silver foil bags and to incorporate humidity and CO_2 sensors that deliver readings via a USB port on the side of the container.

Survitec, one of the first maritime safety companies to offer the extended service solution concept, has carried out a combination of more than 50,000 liferaft exchanges and inspections under the RaftXChange programme since 2012, with technicians recording liferafts in perfect condition even after 30 months of service.



Survitec's award-winning Seahaven concept

The end of the lifeboat?

As it looks to the future, Survitec's latest advanced evacuation system builds on the innovations developed by Dagnall all those years' ago and seems set, once more, to revolutionise maritime safety. Survitec's award-winning Seahaven is capable not only of providing cruise ships with a means of transporting 1,060 persons per craft to safety, but could also make it unnecessary for ships to carry conventional lifeboats. This would free up large amounts of space for more cabins or entertainment areas and open up the view from areas of a ship currently obscured by davit-mounted lifeboats. Seahaven uses two inflatable slides to transfer passengers directly into a pair of powered inflatable lifeboats. One of its novel features is that it allows families to descend as a group, reducing stress and increasing levels of safety during the evacuation process.

Reginald Foster Dagnall, who began his development work in a small shed, applying his own inventive zeal to a particular practical need, would surely approve of this novel innovation. RFD and Survitec have been powered by his driving force throughout the past 100 years and for as long as there are ships, there will be liferafts. And Survitec will continue to protect lives and be at the forefront of their development. *NA*

Avoiding vessel grounding – applying data to learn from past operations

Teemu Manderbacka, lead R&D engineer, NAPA Shipping Solutions, explains how a recent partnership with MOL and ClassNK has given rise to a smart solution for mitigating the risk of grounding

In addition to the global pandemic, 2020 played host to significant grounding disasters, with collisions and grounding the most common cause of incidents in the passenger sector. This is not new; a review of records in the Baltic Sea has shown that in terms of accident occurrence, collisions and groundings are the most common, with collisions accounting for almost 32% of incidents, and grounding/stranding for almost 25%, between 2014 – 2017. More recently, the Japan Transport Safety Board found collisions and groundings to be the most prevalent cause of accidents for all vessels. Alongside other contact incidents, they accounted for 62% of occurances during 2020, as of 30 November.


Teemu Manderbacka

When we look at the potential safety applications of Big Data, research into grounding and collisions, and how best to prevent them, is a natural priority. The continuous advancement in shipping's databases and greater understanding of Big Data analysis enables us to design safer vessels, optimise voyage routes and understand past incidents better to prevent future accidents.

Collaboration is key to unlocking potential

At NAPA, we are driving industry advancement in this area – applying our expertise on projects and collaborating with academics, shipowners and class societies, to increase operational safety out at sea. For example, we recently partnered with Mitsui OSK Lines (MOL) and ClassNK to develop a new software to intelligently monitor and mitigate grounding risks.

The system will be based on NAPA Fleet Intelligence, a platform for ship performance monitoring and voyage planning; it combines real-time data with performance algorithms and modelling to optimise voyages for safety and efficiency. More specifically, the system uses position data, sea depth and weather data alongside navigational charts to provide users with a robust and accurate platform for better monitoring of their fleet. Alerts will be given if vessels deviate from a safe route, or from a reference route – further strengthening ship-shore connectivity to lower the risk of vessel grounding.

Following the verification of the proof-of-concept by MOL in its testing phase, the software's deployment will not only help reduce grounding incidents, but also will be a critical component in shipping's digital evolution. Significantly, we are reaching the point where automatic voyage optimisation can find the most fuel-efficient routes – and also provide weather and risk updates based on a wealth of real-life data. This can further help crew and shoreside teams better assess and avoid risk.

A critical part of a bigger picture

Making this work requires close collaboration, alongside sophisticated software and Big Data expertise. With this in mind, we have been working in partnership with industry leaders in the European Commission-funded FLooding Accident REsponse (FLARE) project, which aims to improve passenger ship safety through conducting vital research into flooding accident response.

NAPA is leading research in the workspace of flooding risk mitigation; using measurements and predictions of progressive flooding to enhance the provision of vulnerability monitoring and survivability assessments. In collaboration with those heading up this field, we are applying the simulation capabilities of the NAPA Emergency Computer, which assesses the vulnerability of an intact ship as well as its survivability in case of a flooding emergency. This research will provide crew with a greater understanding of how their actions will affect the safety and vulnerability of a vessel in any given situation and accelerate ship-shore response with shared situational awareness.

Most recently, we have been able to apply our learnings from the FLARE project to mitigate grounding risk; using Big Data analysis to create a unique model that will enable crew and shore-side operators to better assess and manage the risks of grounding in real-time.

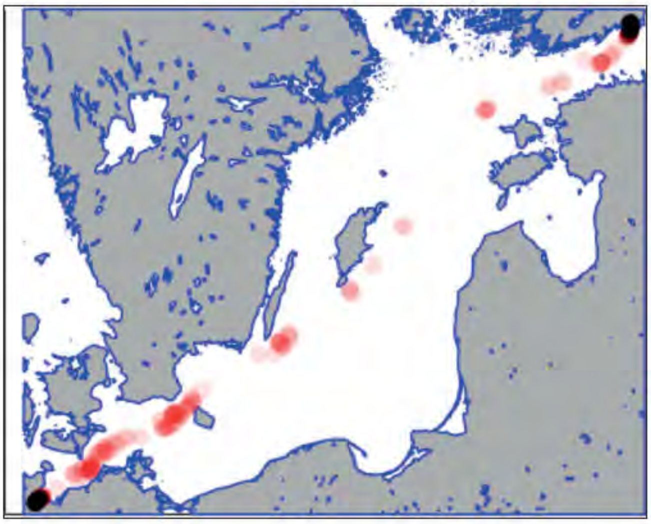
With collisions and grounding common causes of maritime accidents, our solution could help supply an invaluable system to inform crew, and shore-side teams, of the navigational complexities and vulnerability of a vessel. The addition of such information, if applied strategically, has the potential to help us better develop further models to monitor and avoid accidents.

Alongside those leading in the FLARE project, we decided to put this theory to the test; applying the Big Data analytics methodology created in the project to analyse the grounding avoidance behaviour of a selected ro-pax ship. We took detailed traffic data obtained from the AIS for a three-year period of operations in the Gulf of Finland. The developed methodology enabled us to identify the crucial stages leading up to potential vessel grounding and provided us with the information to determine subsequent flooding risk.

Looking to the horizon

Following on from the FLARE project, we believe this vital analysis will play a key role in improving maritime safety standards and culture. The implementation of such research will enable better ship-shore communication; the real-time data analysis and increased automation not only reducing the risk of human error, but also identifying problems before the risk is unavoidable.

Likewise, the continuous development of an all-encompassing data driven solution deployed across large fleets and combining a multitude of factors, like weather, grounding risk, ship stability, fuel efficiency and cargo operations, would allow for greater holistic decision making. The model will provide crew with a means to take action to mitigate the danger by reducing vulnerability in high-risk areas, whilst at the same time informing operation centres on the vessel operations and subsequent dangers.



The movements of a ro-pax were monitored across a three-year period to see how it managed the risks of grounding

The shipping industry relies on its safety credentials to ensure economic stability and progress. Although there are improvements still to be made, we believe that the application of Big Data, continued pursuit of vital research and industry collaboration will contribute to driving up safety standards. *NA*

Cutting out the welding

Fassmer Shipyard makes Roxtec pipe fittings its new standard, eliminating time-consuming and costly welding

Recently, Fassmer Shipyard in Germany opted to make Roxtec pipe penetration seals their new standard, replacing lengthy and expensive welding operations as a matter of course, and improving fire safety in the process. The move was deemed to be highly beneficial. "During construction, we enter multiple pipes through the opening and then adapt the seal to the diameters," says Alla Klatt, senior 3D coordinator at Fassmer Shipbuilding Division. "We can even add pipes later," he notes.

Welding is a hugely costly and time-consuming process for shipyards, and introduces a plethora of factors. It requires significant technical expertise, as well as attendant fire and safety personnel, and third-party inspection.

Whilst welding will remain integral to shipbuilding, repair, maintenance and retrofit programmes, there is one area in particular where methods stand to improve. Up to this point, many pipe penetrations have been connected to a transition piece (bulkhead union) which is subsequently welded directly to both sides of the structure, hence doubling the installation work. The increased levels of exposure to 'hot works', particularly during repairs or retrofit projects, result in anything deemed remotely flammable having to be stripped away from the area of operation. Further, firefighting personnel and equipment have to be on-hand at all times in order to prevent disaster.

Cutting out the middleman

By setting Roxtec pipe seals as its new standard, Fassmer Shipyard has foregone this costly, time-consuming and risky process entirely. Instead, by straightforwardly drilling a hole in the bulkhead, Fassmer can route pipes through and fill the gap with a Roxtec rubber seal.

Will Hoffman, Roxtec

"Welders are skilled tradesmen but despite this, it still takes a significant amount of time to correctly weld a pipe

Fassmer Shipyard, Berne, Germany

or transition piece directly to the ships structure – and the larger the pipe, the longer the welded seam," explains Will Hoffman, Roxtec key account manager, Global Pipe Sealing Solutions, Marine & Offshore. "It's not a job which can be finalised in one go, as cooling intervals are required to complete a large diameter weld. Even getting 'hot work permits' on repair or retrofit projects can amount to a matter of days."

Furthermore, there are times during a newbuild project or drydock when a last minute alteration or addition is required. "Although [pipe] installations are designed and pre-prepared in advance, there are often instances where the project is close to completion, and someone realises there has been a mistake," Hoffman explains. "By this time, the bulkhead is likely primed and painted – now, they have to take away that paint, re-weld, then re-prime and re-paint that damaged area."

Roxtec SPM pipe seals are comprised of a circular rubber-based element that expands via compression bolts to create a tight seal between the outside of the pipe and the inside of the structure opening. The tight seal provides certified protection against fire, gas and water pressure. Completed in moments, only one side of the bulkhead needs be accessible to complete the work, ideal in retrofit settings with inaccessible or potentially fire-hazardous equipment spaces. "In a repair or retrofit scenario with everything already installed, access becomes very difficult," Hoffman adds.

Everything-proof

The risk from fires is of major concern to Roxtec, since all parts of a bulkhead including the pipe penetrations must be capable of containing a blaze. This is one of the most challenging aspects of testing, which takes place at Roxtec's headquarters in Sweden. The fire resistant performance of Roxtec's Roxylon compound (a variant of EPDM rubber with additional fillers and fire retardants) is continuously tested to various levels of fire rating standards. It is certified by DNV GL and all other class societies around the world; but work continues to explore the upper limits of the base rubber compound's capabilities.

"There are two parts of our lab," Hoffman explains. "In the fire lab, Roxtec is burning rubber three or four days a week. We also perform extensive water, gas, stress and exposure testing here. A few years ago we invested very heavily to improve the facilities and capabilities at our rubber laboratory to make it a world class testing facility."

When it comes to pipe penetrations, one eye should be kept on the future, Hoffman indicates – that is, longevity. A seal that is water and gas-tight today might not be tomorrow, unless the right solutions are used. "All pipes vibrate, and anywhere you have forces moving in two different directions – say, a pipe – and the structure it is welded into that forms a potential stress point," he explains.

"Even a tiny hairline crack in that weld can trap moisture or condensation; that's how rust starts to happen. But if the pipe is not in direct contact with the structure because of a rubber ring absorbing that impact, the long-term benefits are less direct stress on those pipe penetrations and reduced long-term risks of corrosion.

Resource and administrative-intensive, welding is a finite process that cannot be easily altered or adjusted. Despite this, welding will always need to be done and the profession is not going anywhere. However, switching out this process in one particular application – pipe penetrations – improves yard efficiency and safety, and maximises flexibility for ship operators as well. *NA*

The Roxtec SPM seal

Achieving efficient scrubber design with two-phase CFD

Two-phase CFD simulation, optimising marine scrubbers for higher performance at the lowest cost. This type of simulation provides detailed understanding of gas-water interaction inside the cleaning unit, making it possible to understand how to reach maximum efficiency

Marine scrubbers are typically used to remove SOx from engines. This allows ships to control their emissions and therefore comply with environmental regulations.

When it comes to the operation of scrubbers, the focus is placed on getting the best ratio between price and functionality. An optimal way of addressing this is by performing a CFD analysis in the design phase ensuring maximum emission reduction, while:

- minimising the amount of water and limestone slurry used to clean the flue gas
- reducing the marine scrubber size
- minimising pressure drop

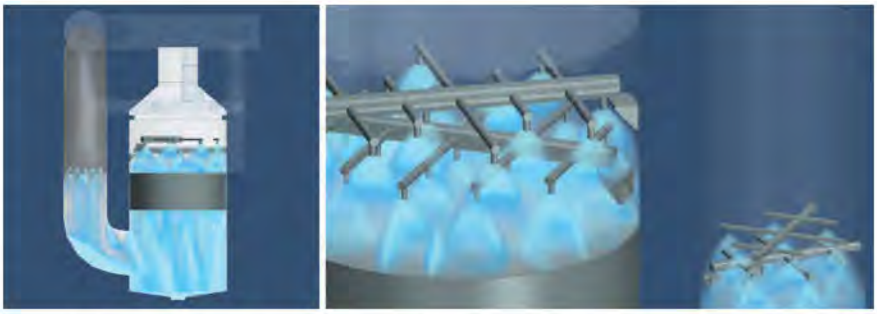


Figure 1. Gas-water interaction inside two-phase CFD simulation of scrubber

Optimal design of the marine scrubber results in cost reduction both in the initial investment and during operation. Additionally, operation downtime due to troubleshooting is minimised.

Detailed understanding of gas-water interaction

Two-phase Computational Fluid Dynamics (CFD) simulations account for gas-water interaction, and they provide an accurate prediction of what exactly is happening inside the scrubber. This is crucial to properly quantify both gas-water and flue gas velocity distribution, as well as system pressure drop, since single phase simulations do not account for the effect of injected material on the gas, which would lead to erroneous results.

Understanding such flow details inside the scrubber enables effective design and simulation testing of:

- pattern layout of injection nozzles
- trays
- packed beds

Optimal design prior to manufacturing

Detailed two-phase information allows for the creation of a design that functions optimally before manufacturing. This simulation-driven design approach is much more affordable than the traditional process based on trial and error of numerous built and tested prototypes. Additionally, the information obtained through measurements is typically limited to a few data points, making it hard to understand and optimise the internal processes of the scrubber.

Figure 2. Mass fraction of water at different planes inside two-phase CFD simulation of a scrubber

Design & troubleshooting

If enough computational resources are not available, two-phase simulations can be time consuming. Further, experienced engineers with knowledge on marine scrubbers, CFD and two-phase flow are necessary not only to prepare accurate models, but also to analyse results correctly and propose valid improvements for the equipment.

For wet scrubbers, two-phase models are much more realistic than one-phase models. Two-phase CFD simulations account both for the flue gas inside the scrubber and the water injected to clean the gas, allowing an accurate projection of how the flue gas is affected by the water. On the contrary, one-phase simulations only consider the gas inside the scrubber and will therefore predict incorrect flow, temperature distribution and pressure drop, since they neglect the effect of the water on the gas. In order to design a scrubber of maximum efficiency using CFD, one must use models that will capture internal phenomena correctly when compared to reality. This is why two-phase models are more suitable for scrubber optimisation. *NA*

Getting the most out of CFD, a short guide

CFD is most useful if you ask the right questions, and if you know how to avoid going in the wrong direction with a project, writes Inno Gatin of consultancy Cloud Towing Tank

Getting the most out of any engineering tool requires some knowledge of its limitations and capabilities. CFD is no different, but where it does differ from most tools is in the highly specialised knowledge and skill needed to harness its potential. As a result, ship designers and operators hire specialised CFD engineers, who often speak a different technical language. This creates a problem in communication and understanding between the two parties, which can lead a CFD project in the wrong direction, wasting time and money. In addition, otherwise useful engineering intuition can sometimes get us in trouble when it comes to accuracy of the CFD method.

There are many applications of CFD in the marine industry, however most studies can be reduced to two basic categories of simulations: calm water resistance and self-propulsion. For ship design CFD can offer accurate resistance assessments of high quality, especially when relatively small changes to the geometry need to be studied, which cannot be accounted for with empirical relations. In certain cases, self-propulsion simulations are more useful since they provide the shaft power directly, without applying empirical methods to derive the propulsion coefficients. For ship operations CFD can help save fuel using a database of self-propulsion results at different trims, allowing for trim optimisation. Of course, CFD is a general method, and many more applications can be found. The above is just a short cross-section of the most frequent projects encountered in the industry.

In the text below, we try to give a short guide for interpreting some aspects of a CFD project that often lead to misunderstandings and waste of resources.

Precision and accuracy: know the difference

Often confused and used as a synonym, precision and accuracy mean two different things, and both are important when analysing CFD results. Precision is the property of a method related to uncertainty, i.e. the greater the uncertainty of the method the smaller the precision. In the case of CFD, we are mostly interested in uncertainty related to the change of the resolution of the computational grid, i.e. if we change the number of cells. Accuracy, on the other hand, is how well the result of a method or model corresponds to the phenomena it is supposed to describe. In our case, how close does our CFD result come to experimental or sea trial measurements.

In the following text we will deal with both precision and accuracy, as both often lead CFD projects in a wrong direction.

Precision: grid convergence and uncertainty

Although CFD stands for Computational Fluid Dynamics, and thereby represents any numerical method that deals with fluid dynamics, colloquially CFD stands for the Finite Volume method. In the Finite Volume approach, the fluid domain is discretised using simple geometric bodies such as hexahedra, pyramids, or prisms, known as cells, which make up the computational grid (Figure 1 and Figure 2). The complex and nonlinear fluid flow equations are then simplified in these individual units in a way that allows us to solve them using a computer. The smaller the cells are, the greater their number and the better the resolution of the flow.

One of the questions often posed to a CFD engineer, from his CFD colleagues as well as from other engineers, is: "Have you conducted a grid uncertainty/convergence study?". The trap here is that within these two variants of the sentence lay two very different, but related, questions. If the wrong version of the question is posed to a CFD expert, a lot of resources can be wasted for nothing. Before presenting this question to your CFD engineer, make sure you know exactly what you need.

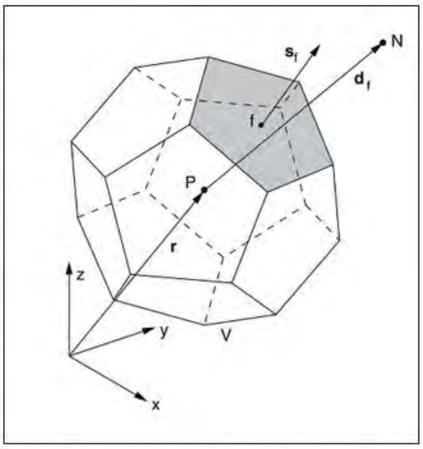


Figure 1. Depiction of a Finite Volume cell from (Vukčević, Jasak, and Gatin 2017)

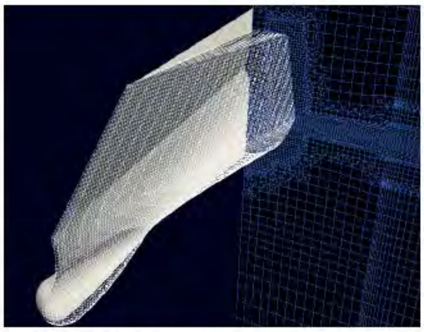


Figure 2. Computational grid of the ONR Tumblehome ship

Identical procedure is required to calculate grid uncertainty and convergence. The approach involves repeating the same calculation with at least four different computational grids. If you need to conduct the study for more conditions (e.g. multiple ship speeds or drafts), the amount of calculations quickly grows to a very high, and therefore expensive, number. Roughly speaking, the grid convergence or uncertainty study, if done right, increases the cost of the CFD study by at least four times.

Grid convergence is used in very different circumstances compared to grid uncertainty studies. Grid convergence study is mainly performed only once for

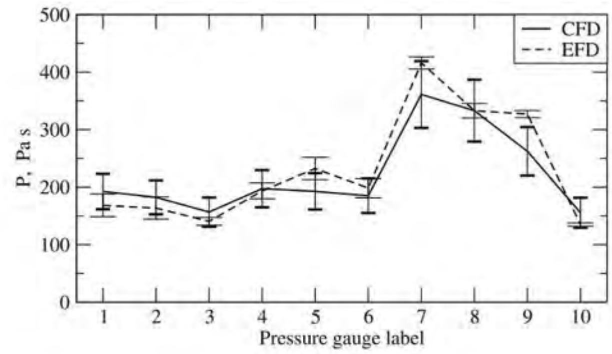


Figure 3. Example of CFD and Experimental Fluid Dynamics (EFD) results with uncertainty intervals from (Gatin et al. 2018). The CFD uncertainty intervals are obtained by performing a grid uncertainty study. The graph compares peak pressure during a green water event

a given numerical method, whereas grid uncertainty study can be conducted for every project. In short, the former study tells you about the quality of the numerical method, i.e. the CFD software, while the later study gives you an uncertainty estimate for your specific problem, e.g. the uncertainty interval of the resistance force for the specific ship at hand. Read below for more details on convergence and uncertainty.

When a new CFD method is developed, it is necessary to check whether the solution becomes more precise with increasing the resolution of the grid. In other words, the solution is supposed to be changing less and less between two grids as the computational cells become smaller. This process is known as solution verification or grid convergence study (Eça & Hoekstra, 2014). The main purpose of this study is confirming that the developed code solves the physical problem in a mathematically consistent way. It only needs to be done once for a class of problems, such as calm water resistance or seakeeping. This means that if you are interested in whether the software that your CFD provider/employee uses is of good quality, you need to ask them for a grid convergence study. In many cases, this study has already been performed for your class of problems, since this is typically a first step the scientific community performs after developing or purchasing a new code. The results are often published in the form of scientific papers which are readily accessible. The thing is, if you find a publication where the software that your CFD provider is using is verified, you do not need to conduct the grid convergence study yourself. Given that you can trust the source of the study, you can assume that the grid convergence results apply to yours as well.

Even though grid convergence study indicates the uncertainty intervals for the class of problems at hand, these are not specific to your problem, i.e. ship. If, however, you require uncertainty intervals for your specific problem, then and only then insist that your CFD expert conducts a grid uncertainty study.

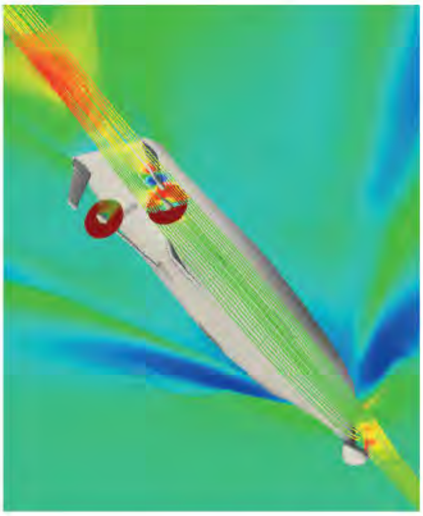


Figure 4. CFD simulation of a full-scale sea trial

When to conduct a grid uncertainty study?

If you need to know roughly how precise the CFD results are, you can save time by consulting results of grid convergence studies for your type of problem in literature, or your own uncertainty study from a previous project. Generally speaking, this will give you a good idea on what to expect.

There are situations, however, where you need to know exactly what your uncertainty intervals are, and in this case the grid uncertainty study can be useful (Figure 3). For example, if you are comparing two variants of the same vessel's hull in terms of resistance, you might want to compare the difference in resistance between the two variants with uncertainty intervals. If the difference is smaller than the uncertainty, then the results do not tell you clearly which option is better.

Accuracy: comparison of CFD to experiments and sea trials

The single most important information you need about the CFD results you receive is accuracy: how well do the results describe the phenomena they are supposed to model? CFD is a relatively young method when it comes to marine hydrodynamics, and it still needs to prove itself to this very traditional industry. After all, ships have been sailing for thousands of years and mature CFD solutions for these types of problems have become accessible only recently. Therefore, many CFD projects in the marine industry begin with a reference run, where a CFD simulation is performed for a ship that has been designed in the past, and for which experimental data exists to allow for a comparison. Once these figures come in, the quarrel begins. In many cases, a gap of 5% in resistance between CFD and towing tank results will not be tolerated. Often the allowed difference is in the range of 1-2%, and we have our engineering intuition to blame for this. When presented with a very modern, high fidelity method like CFD, most engineers expect better than 5%. In the following text, we will try to depict how this sort of accuracy goal leads to frustration and waste of resources in many cases, and why.

Uncertainties: towing tank experiments and sea trials

Towing tank experiments are trusted within the marine industry for a good reason: they have been in use, very successfully, for a century. The methods used in experimental facilities are tested repeatedly, and the instruments only get more precise as technology evolves. This is also why towing tank results are everyone's favorite when it comes to validating CFD results. It is useful, however, to put things in perspective, and to remember what both experiments and CFD are trying to predict. The end goal is to predict hydrodynamic characteristics of an actual vessel in full scale. Having this in mind, the accuracy of both family of methods can only be assessed by comparing them to sea trials.

All engineering methods suffer from uncertainties, there is no way around that, but it is very important to know their approximate magnitude and sources. For validating CFD results, it is important to put the errors of CFD compared to towing tests or sea trials in perspective with their uncertainties.

In their paper presented at the HullPIC 2020 conference, (Werner and Gustafsson, 2020) reported an uncertainty analysis of a collection of speed trial data and corresponding model tests conducted at SSPA, Sweden. The study encompassed 14 series with five or more sister vessels in each, where the analysed quantity is the delivered power measured at the sea trial. Theoretically, sister ships are supposed to have the same delivered power since they are geometrically identical. Any changes between the power measured onboard identical vessels presents the uncertainty of the sea trial measurement and due to building differences. After all, ships are fairly complex and it's really optimistic to expect that all the pieces of the puzzle should come together in exactly the same way. Werner and Gustafsson report that on average the precision error is 8.5% in delivered power, ranging from 5% to 12% for individual series. For one ship series, the largest difference of measured power with respect to the average of measured powers for all vessels, was as high as 15% (Figure 1 from [Werner and Gustafsson, 2020]). This data is in line with other similar studies; (Insel, 2008) reports a 7% precision error for a series of ferries. But the story does not end at these 7-8.5%, because bias needs to be superimposed with precision uncertainty to get the total uncertainty. (Werner and Gustafsson, 2020) note that adding the estimated bias results in overall uncertainty of 10%.

When it comes to towing tank experiments, their precision and uncertainty is very low, and there is a high level of confidence present when it comes to resistance measured in experimental facilities in model scale. The uncertainty, however, comes from scaling the results to full scale. According to (Bose and Molloy, 2009), the three largest sources of uncertainty when scaling results are model-ship correlation line, form factor estimation and correlation allowance. The model-ship correlation line is a formula based on empirical data allowing the estimation of viscous resistance of a flat plate, which is essential for scaling the model scale results to full scale. Molloy notes that the assessed uncertainty of the correlation line can result in delivered power uncertainty in full scale of 6.6%. Form factor estimation can lead to uncertainties of around 7.6%, and correction allowance up to 6.1%.

In the light of the presented uncertainties, it can be concluded that at the current level of precision exhibited by sea trial data, no prediction method (towing tank experiments or CFD) can be validated to a precision smaller than 10% (Werner and Gustafsson, 2020). It makes little sense, therefore, to insist on 1-2% of difference between CFD and experimental data. This is especially true for CFD simulations which are performed directly in full scale, since the experimental data needs to be scaled to allow comparison, and this involves the above-mentioned uncertainties. *NA*

Summary

Before commencing a CFD project with your employee or consultant, here are the things you should know:

- Know the difference between precision and accuracy of the CFD method.
- If you are interested in the overall validity of the CFD method, ask for grid convergence data from past studies. This will save precious resources.
- If you need to know the uncertainty intervals for your specific project, ask for a grid uncertainty study. Beware that this will increase the cost of the study by roughly four times, if done right.
- Before judging whether the CFD results are sufficiently accurate compared to experimental results or sea trial data, remember that the uncertainty of sea trials is around 10%.

About the author

Inno Gatin is a naval architect and CFD engineer at the Cloud Towing Tank consultancy company. He acquired his PhD in the field of CFD software development with a focus on marine hydrodynamics.

References

1. BOSE, NEIL, and SUSAN MOLLOY. 2009. "*Reliability and Accuracy of Ship Powering Performance Extrapolation.*" First International Symposium on Marine Propulsors (June). http://www.marinepropulsors.com/proceedings/MB1-1-Bose - Reliability and Accuracy of Ship Powering Performance Ext.pdf.
2. GATIN, INNO *et al.* 2018. "*CFD Verification and Validation of Green Sea Loads.*" Ocean Engineering 148: 500–515.
3. INSEL, M. 2008. "*Uncertainty in the Analysis of Speed and Powering Trials.*" Ocean Engineering.
4. VUKČEVIĆ, VUKO, HRVOJE JASAK, and INNO GATIN. 2017. "*Implementation of the Ghost Fluid Method for Free Surface Flows in Polyhedral Finite Volume Framework.*" Computers and Fluids 153: 1–19. http://dx.doi.org/10.1016/j.compfluid.2017.05.003.
5. WERNER, SOFIA, and LARS GUSTAFSSON. 2020. "*Uncertainty of Speed Trials.*" In HullPIC 2020, 28–36.

How does the surrounding built environment affect the wind forces on moored ships in ports?

A joint project between the Eindhoven University of Technology and the Port of Rotterdam has shown that wind forces on moored cruise ships are strongly influenced by the built-up area near the port

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Measured wind forces on ships in open sea may be very different than those measured on vessels moored in port areas since the latter can highly depend on the surrounding buildings, cranes and other infrastructures. The knowledge of these forces is important for safely manoeuvring and mooring the ships inside the complex environment of port areas (Solari *et al.*, 2012).

The present policy in most ports worldwide is that ships are only admitted when, for a particular wind direction, the expected wind speed during the manoeuvring operations are predicted to remain below a certain threshold wind speed. However, this speed is generally measured at a fully exposed reference position.

The presence of buildings and other infrastructures in port areas, however, can increase or reduce the local wind speed and introduce large wind speed gradients, yielding higher or lower wind forces and moments than those that would occur in open sea (Thoresen 2014). Therefore, more precise knowledge of wind forces on ships in the port and the ability to predict them is required to fine-tune the admission policy of ports. Such information is also required for the tugboat pilots as it provides them the necessary input for safely manoeuvring the vessel but also for their training in manoeuvring simulators.

Wind forces on ships at open sea conditions are generally determined by either wind-tunnel tests on reduced-scale models or by Computational Fluid Dynamics (CFD) simulations. While most CFD studies focused on wind loads on a ship in open sea-like conditions (e.g. Wnęk and Guedes Soares, 2015), only a very limited number have been considering more complicated wind conditions developing throughout seaport areas (e.g. Blocken *et al.*, 2015; Ricci *et al.*, 2020a; Ricci and Blocken, 2020b).

The present study investigates the wind forces on a cruise ship, *Oasis of the Seas*, moored at the quay of the Rotterdam Cruise Terminal by 3D steady Reynolds-Averaged Navier-Stokes (RANS) simulations. The Rotterdam Cruise Terminal is situated approximately 30km inland and is located close to Rotterdam city centre (Fig. 1). This area, so-called Kop van Zuid, is a newly developed area also known as 'Manhattan on the Maas' because of the presence of a cluster of high-rise buildings. In September 2014, one of the largest passenger ships in the world, *Oasis of the Seas*, berthed for the first time at the renewed Cruise Terminal in Rotterdam.

In this study, the CFD simulations will be accompanied by a validation study based on extensive on-site wind speed measurements. Then, the wind forces exerted on the *Oasis of the Seas* will be evaluated based on the RANS simulations. A previous study by Janssen *et al.* (2017), in which wind forces on a container ship in open sea-like conditions were determined by 3D steady RANS simulations and validated by wind-tunnel tests (by Andersen, 2013), has been taken into account in the present study to justify the level of geometrical simplification of the ship and the use of the steady RANS approach for evaluating the forces.

CFD validation of wind velocities near Cruise Terminal

A measurement campaign was performed in order to provide both experimental data for CFD validation and real-time input data of reference wind conditions for the actual assessment of wind conditions during the

Fig. 1. Rotterdam Cruise Terminal. Source: Google Earth

days of mooring the cruise ships.

Four 3D ultrasonic anemometers were installed on the quay at 10m above the ground (Fig. 2a-c) and a fifth 3D ultrasonic anemometer was placed on the roof of the World Port Centre (WPC) building (Fig. 2b). This last position was also chosen as reference position and the measured mean wind speed was denoted U_{ref}. Because this measurement position was on top of one of the highest buildings in the area, it would only be influenced by other high-rise buildings for a few specific reference wind directions (Fig. 2b). The total measurement height was about 133m above NAP (Normaal Amsterdams Peil). The measurements were performed at a sampling rate of 1Hz and averaged into 10-min data of mean wind velocity and wind direction. The 10-min averaged data at positions 1 to 4 were converted into wind speed ratios ($\gamma = U/U_{ref}$). These ratios were clustered into 12 wind direction sectors around the median values 0°, 30°, 60°, ..., 330°.

For the validation study, the Cruise Terminal without berthed ships was considered. The computational domain had dimensions 6.6 x 6.6 x 1.0km³. The bottom of the domain consisted of a circular area of interest with a radius of 1,500m that contained the explicitly modelled buildings and a square domain around it in which buildings were modelled implicitly. A high-resolution computational grid was created following the best practice guidelines by Franke *et al.* (2007), Tominaga *et al.* (2008) and van Hooff and Blocken (2010). The resulting grid counted approximately 55 million cells, mostly of the hexahedral type. (Fig. 2d).

At the inlet of the domain a standard logarithmic mean wind speed profile was imposed to represent a neutral atmospheric boundary layer (ABL) wind. Two different aerodynamic roughness lengths z_0 were used: z_0 = 0.5m for the wind directions 30°, 90° and 240°, and z_0 = 1m for the other wind directions.

CFD simulations were carried for 12 wind directions (i.e. 0°, 30°, 60°, ..., 330°) by the 3D steady-state RANS approach and the realisable k-ε turbulence model using the commercial code ANSYS Fluent 15. Second-order discretisation schemes were used for both the convective and viscous terms of the governing equations. The SIMPLEC algorithm was used for pressure-velocity coupling and second order pressure interpolation is used.

Fig. 2. (a-c) Location of measurement positions 1-5. (d) Computational grid of the Cruise Terminal and surrounding area. Total cell count is about 55 million. Figure modified from Ricci et al. (2020a)

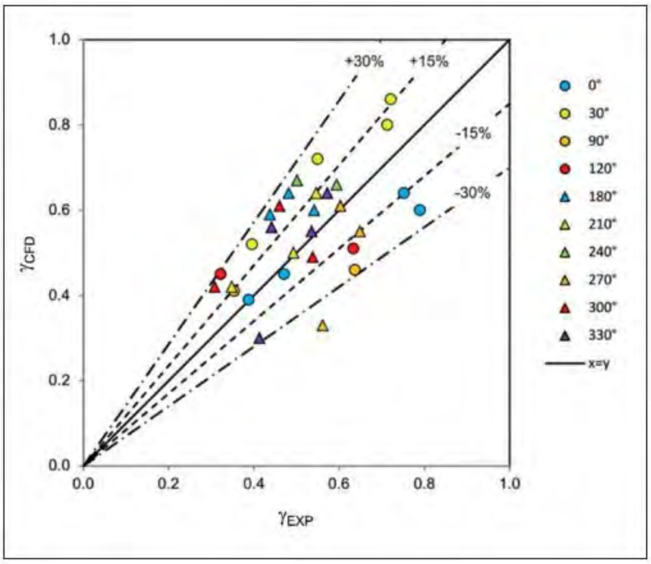


Fig. 3. Comparison between simulated and measured wind speed ratios (γ) for the four near-ground measurement positions and for all reference wind directions (θ). Figure credit to Ricci et al. (2020a)

Fig. 3 summarises the results for all reference wind directions. A good agreement was generally observed with deviations between CFD and measurements of about 30%. This deviation was likely the combination of an ensemble of deviations caused by the geometrical simplifications introduced to buildings and other obstacles, the surface roughness applied to the ground, the adopted steady RANS approach and the selected turbulence model (Ricci *et al.*, 2020b).

In particular, the inability of the steady RANS approach to accurately predict separation and recirculation and von Kármán vortex shedding in the wake could be considered as a main contributor to the deviations. Instead of 3D steady RANS approach, one could consider Large Eddy Simulation (LES) or hybrid RANS/LES approaches, however at a much higher effort and computational cost.

The CFD simulations for the Cruise Terminal with the cruise ship *Oasis of the Seas* berthed along the quay were then based on the present validation study and the results by Janssen et al. (2017).

CFD simulations with cruise ship moored at the quay

Mean velocity field and pressure coefficients: In this part of the study, the *Oasis of the Seas* was moored at the quay of the Cruise Terminal (Fig. 4). The computational domain and grid were the same as in the validation study apart from the addition of the cruise ship. The grid around the ship had a higher resolution in order to include more details of the ship superstructure. The surface of the vessel was discretised with cells of about 1 x 1m². The resulting grid counted about 58 million, in this case also mostly composed of hexahedral cells. The boundary conditions and solver settings were identical to those in the validation study and the simulations were carried out for the same 12 reference wind directions (i.e. 0°, 30°, 60°, …, 330°). As an example, Figs. 5 and 6 show the CFD contours of the mean wind velocity field at a height of 5m above NAP and the mean pressure coefficients (C_P) on the ship exterior surfaces, for four of the reference wind directions (i.e. 0°, 120°, 180° and 270°), respectively. The mean pressure coefficient (C_P) on the cruise ship is calculated by Eq. 1:

$$C_P = \frac{(P - P_0)}{\frac{1}{2}\rho U\frac{2}{ref}} \quad (1)$$

where P is the mean static pressure on the surface, P_0 the reference atmospheric mean pressure and U_{ref} the mean wind speed at the reference position.

In general, the CFD contours show that the wind approaching the moored cruise ship is strongly affected by the surrounding constructions such as buildings. The following observations can be made on Figs. 5 and 6:

For $\theta = 0°$ (Figs. 5a-6a), the vessel is partly sheltered from wind by the built-up area on the other side of the shore. The windward side shows C_P values from 0.2 to 0.4. The leeward side of the ship shows near-zero C_P values for the half of the surface near the bow and positive C_P values for the half of the surface near the stern of the vessel.

For $\theta = 120°$ (Figs. 5b-6a), the cruise ship is partly sheltered from wind from the high-rise buildings on the quay. The jet passing between the buildings on the quay impinges on the windward side of the vessel yielding C_P values of about 0.5. On the leeward side of the ship, the C_P values are slightly positive, indicating the absence of large flow separation regions around the vessel.

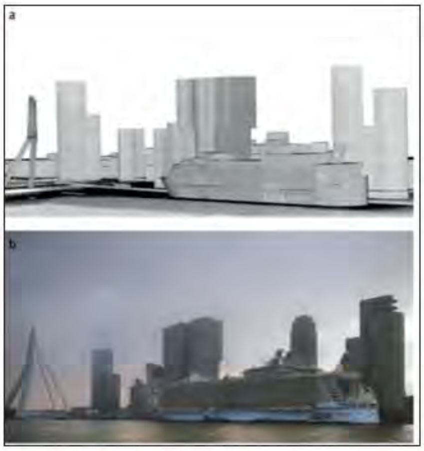


Fig. 4. (a) Detailed view of the computational grid and (b) corresponding photograph (source: NOS.nl). Total cell count for whole domain is about 58 million. Figure modified from Ricci *et al.* (2020a)

For $\theta = 180°$ (Figs. 5c-6c), the cruise ship is weakly sheltered from wind by the high-rise buildings. The wind flows through the large passage between the WPC building and the other buildings and impinges on the windward side. The strong impinging flow yields a strong flow over the ship, and the associated large areas of flow separation over the ship. These in turn yield negative C_P over almost the entire leeward side of the vessel.

For $\theta = 270°$ (Figs. 5d-6d), the cruise ship is partly sheltered from wind by distant upstream buildings. The C_P values on the windward side are generally positive. On the leeward side, the C_P varies in a range of about - 0.2 and + 0.2.

Wind forces on *Oasis of the Seas*: Wind forces on the ship *Oasis of the Seas* moored at the quay of the Cruise Terminal of Rotterdam Port are calculated for all reference wind directions in dimensionless form by Eqs. 2-4 and reported in Table 1:

$$C_x = \frac{X}{\frac{1}{2}\rho U^2 A_f} \quad (2)$$

$$C_Y = \frac{Y}{\frac{1}{2}\rho U^2 A_S} \quad (3)$$

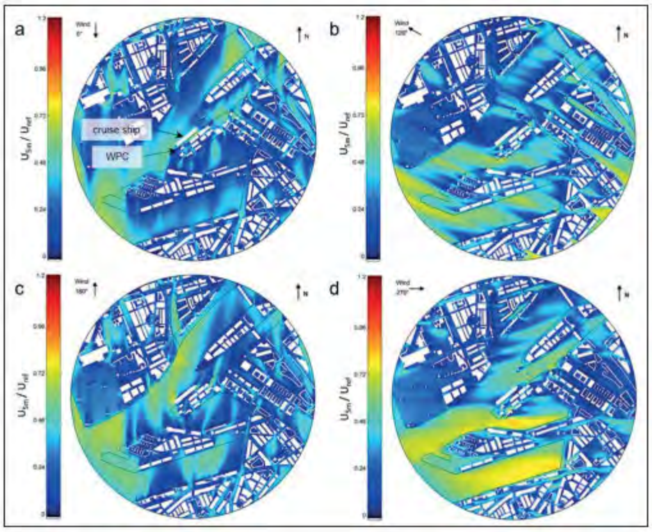


Fig. 5 (a-d) CFD contours for 0°, 120°, 180° and 270°: wind speed ratio U_{5m}/U_{ref} in the study area. U_{5m} is the local mean wind speed at 5m above NAP and Uref is the mean wind speed at the reference location on top of the WPC. Figure modified from Ricci *et al.* (2020a)

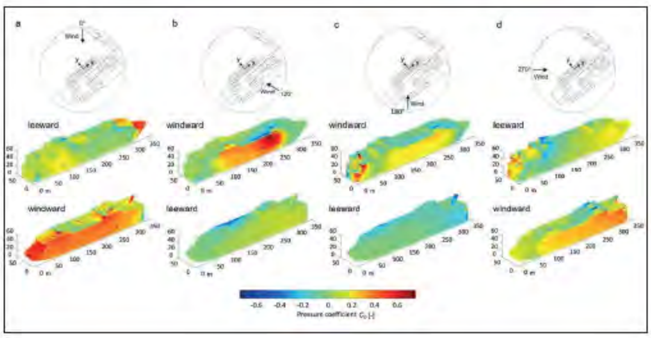


Fig. 6. Mean pressure coefficient C_P on the ship exterior surfaces for four reference wind directions (a-d): 0°, 120°, 180° and 270°. Figure modified from Ricci *et al.* (2020a)

$$C_N = \frac{N}{\frac{1}{2}\rho U^2 A_S L_{oa}} \quad (4)$$

where U_{wpc} is the velocity reference taken at position 1 (i.e. the reference position on the roof of the WPC building), A_f the projected front area, A_s the projected side area and A_t the projected top area of the ship.

Fig. 7 shows the results with the forces indicated in the center of pressure (CoP) for four of the reference wind directions (i.e. 0°, 120°, 180° and 270°). In general, the CoP is always located on the vessel except for $\theta = 240°$. For this reference wind direction, the wind blows on the stern of the ship and forces are minimal with respect to other wind directions where the lateral sides of the vessel are completely exposed to the wind. Although for this wind direction no tugboats are required, ship direction throughout the port will not always be parallel to the wind direction and in the worst scenario the wind could strongly push the vessel towards the quay.

These coefficients can be used in combination with the measurements at the reference position to determine the expected forces on the ship and berth requirements such as safe working loads of bollards and fenders. To assess the influence of upstream nearby high-rise buildings, the side and vertical force coefficients (C_Y, C_Z) are compared for all analysed wind directions. In general, through a comparison of some wind directions (as 0° vs. 120°) it is found that the net result of the buildings on the ship was to provide some shelter (lower C_Y values) even though the highest local C_P on the vessel's surface was found for the sheltered case ($\theta =$ 120°). For 120° a larger C_Z value was found, indicating that the upstream buildings increase the upward force (Table 1).

Table 1. Force coefficients on the *Oasis of the Seas*

reference wind direction	C_X [-]	C_Y [-]	C_Z [-]
0°	-0.35	-0.25	0.09
30°	-0.46	-0.14	0.12
60°	-0.18*	0.14*	0.08*
90°	0.10	0.19	0.24
120°	0.01	0.19	0.26
150°	-0.42*	1.02*	1.03*
180°	0.27	0.28	0.21
210°	0.33	0.19	0.08
240°	0.43	0.00	0.00
270°	0.20	-0.19	-0.03
300°	-0.06	-0.37	0.11
330°	-0.26	-0.34	0.09

*Reference position in wake of nearby high-rise buildings.

Conclusions

This study has shown that the presence of high-rise buildings nearby the port generally increases the gradients in surface pressure over the moored ship's surface. The presence of the high-rise buildings can produce amplified surface pressure, but due to the large size of the vessel, it was found that the net horizontal force decreases.

This is due to the fact that the ship's length is much larger than the width of the buildings, by which some parts of the vessel's lateral surface are sheltered, while others are more exposed. For smaller ships, nearby high-rise buildings can yield net increased or decreased horizontal lateral forces, depending on the wind direction and the relative position of vessel and buildings.

For the *Oasis of the Seas* it was found that the net vertical upward force increases. This can be attributed to the fact that the highest wind speed amplification around high-rise buildings occurs around near ground level, i.e. at the base of the buildings, and that this flow impinges at the bottom of the windward side of the ship and is then deviated upwards along the vessel's surface.

In conclusion, complex environments may cause non-uniform wind fields that will influence the navigation and manoeuvring of ships in port areas, in particular those vessels with high windage areas. The wind field can cause forces and moments that manoeuvring ships (with or without the assistance of tugs) must be able to compensate. Simulations of port areas including real-time wind fields will allow port authorities to accurately determine limiting wind velocities for specific types and sizes of ships, which may result in an economical benefit for the ports since narrower safety margins than necessary could be considered when mooring and manoeuvring ships. *NA*

References

1. ANDERSEN, I.M.V., 2013. *Wind loads on a post-panamax container ship*. Ocean Engineering 58: 115-134.
2. BLOCKEN, B., VAN DER HOUT, A., DEKKER, J., WEILER, O., 2015. *CFD simulation of wind flow over*

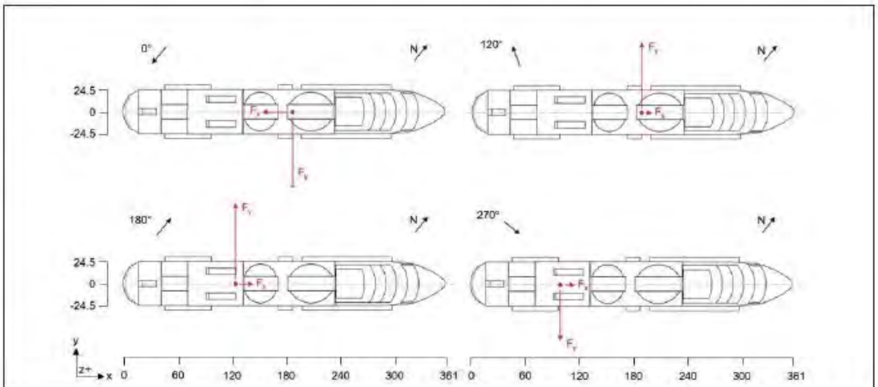


Fig. 7. Center of pressure (CoP) of the wind forces on the cruise ship *Oasis of the Seas* for four of the reference wind directions (θ) analyzed: 0°, 120°, 180° and 270°. Figure modified from Ricci *et al.* (2020a)

natural complex terrain: Case study with validation by field measurements for Ria de Ferrol, Galicia, Spain. Journal of Wind Engineering and Industrial Aerodynamics 147, 43-57.

3. BLOCKEN, B., 2014. *50 years of Computational Wind Engineering: Past, present and future.* Journal of Wind Engineering and Industrial Aerodynamics 129, 69-102.
4. FRANKE, J., HELLSTEN, A., SCHLÜNZEN, H., CARISSIMO, B., 2007. *Best practice guideline for the CFD simulation of flows in the urban environment.* COST Action 732: Quality Assurance and Improvement of Microscale Meteorological Models.
5. JANSSEN, W.D, BLOCKEN, B., VAN WIJHE, H.J., 2017. *CFD simulations of wind loads on a container ship: validation and impact of geometrical simplifications.* Journal of Wind Engineering and Industrial Aerodynamics 166, 106-116.
6. RICCI A., JANSSEN, W.D., VAN WIJHE, H.J., BLOCKEN, B., 2020a. *CFD simulation of wind forces on ships in ports: Case study for the Rotterdam Cruise Terminal.* Journal of Wind Engineering and Industrial Aerodynamics 205, 104315.
7. RICCI A., BLOCKEN, B., 2020b. *On the reliability of the 3D steady RANS approach in predicting microscale wind conditions in seaport areas: The case of the IJmuiden sea lock.* Journal of Wind Engineering and Industrial Aerodynamics 207, 104437.
8. SOLARI, G., REPETTO, M.P., BURLANDO, M., DE GAETANO, P., PARODI, M., PIZZO, M., TIZZI, M., 2012. *The wind forecast for safety management of port areas.* Journal of Wind Engineering and Industrial Aerodynamics 104-106, 266-277.
9. THORESEN, C.A., *Port Designer's Handbook.* Third Edition. Published by ICE Publishing, One Great George Street, Westminster, London SW1P 3AA. ISBN 978-0-7277-6004-3.
10. TOMINAGA, Y., MOCHIDA, A., YOSHIE, R., KATAOKA, H., NOZU, T., YOSHIKAWA, M., SHIRASAWA, T. 2008. *AIJ guidelines for practical applications of CFD to pedestrian wind environment around buildings.* Journal of Wind Engineering and Industrial Aerodynamics 96(10-11), 1749-1761.
11. VAN HOOFF, T., BLOCKEN, B., 2010. *Coupled urban wind flow and indoor natural ventilation modelling on a high-resolution grid: a case study for the Amsterdam ArenA stadium.* Environmental Modelling and Software 25, 51-65.
12. WNĘK, A.D., GUEDES SOARES, C., *CFD assessment of the wind loads on an LNG carrier and floating platform models.* Ocean Engineering 97, 30-36.

Ship propulsion 'in behind' optimisation by CFD

VICUSdt's Adrián Sarasquete explains the company's methodology for understanding the hydrodynamic interactions between the components of a ship's propulsion system

The entire shipbuilding industry is aware of the market demands for more efficient, silent and comfortable ships which must be developed in increasingly shorter periods. Shipyards, shipowners and ship designers must adapt to these challenges by using the most up-to-date tools to optimise the performance of their vessels. By making the right decisions from the earliest stages such as conceptual design, design problems can be prevented that otherwise would affect the ship throughout its operational life. The recent development of new and more powerful CFD numerical simulation tools and increased calculation capacity has allowed an evolution in the simulation possibilities and a much more dynamic approach to the design spiral.

VICUSdt has developed its own methodology for the ship hull and propulsion system optimisation that makes it possible to shorten times in the initial phases of the project and to quantify more precisely the interaction between the different components. If we evaluate, for example, the development of an actual multipurpose (MPP) cargo ship project and focus on the 'behind' optimisation of the stern body, propeller and rudder using CFD, we can highlight the following main interactions between the different components.

Upstream Propeller. MPP at operational speed. Resistance calculation

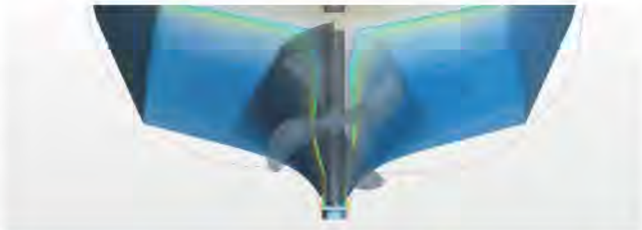
Upstream propeller

Leaving aside the resistance, the ship wake is the main effect of the hull upstream the propeller. A good uniformity of the wake allows to optimise the design of the propeller in terms of its area, pitch distribution and profiles, carrying out a less conservative design. CFD analysis with rotating propeller makes it possible to see the effect of changes in the stern shape almost in real time on the propeller, both for performance and cavitation.

It is still common in the industry to use averaged axial wake values to determine the design of a propeller. But with this methodology it is relatively easy and cost effective to be able to evaluate the wake from its axial, radial and tangential components affected by the propeller itself, which influence the propulsive coefficients (performance).

The swirl (rotation) of the fluid generated upstream of the propeller is easily assessed with the CFD code and manipulated by varying the geometries, being able to improve the performance of the propeller indirectly.

Thrust deduction accounts for the propeller thrust percentage which is lost while operating behind the ship. This important parameter can be modified with the position of the propeller relative to the hull and the design of the propeller. Parameters such as rake or diameter are key. Sometimes an increase in diameter leads to an improvement in performance that is reduced by a parallel increase in suction. Integrating the pressures on a specific area of the stern makes it possible to quantify small changes in hull and propellers from the suction point of view.



Propeller Plane. Operating propeller with induced pressure field on the hull

Downstream Propeller. Pressure field over Hull and flow over twisted rudder

Propeller plane

With regards to the propeller, the traditional design process uses a wake velocity field obtained from a towing tank test or CFD already given without the possibility of making changes without incurring in higher costs (new tests). The 'behind' optimisation allows to dynamically design the propeller while modifying the hull and quantifying the result in terms of absorbed power, speed, or cavitation volume.

It is very common to have a design criteria that requires a compromise solution, such as obtaining high performance for consumption and/or speed but without penalising noise (comfort). With this methodology it is feasible to determine the best solution suiting all aspects.

As the conditions of comfort and noise in ships are more and more demanding, it is not possible to leave cavitation to chance, which many projects cannot afford to evaluate due to budget reasons. CFD analysis brings the opportunity of providing this type of analysis for a wider range of owners and shipyards interested in delivering a higher quality end product.

Cavitation shows up in various ways on the propeller, affecting the noise and vibrations generated by the propulsion of the ship and in more severe cases, the integrity of the propeller (erosion) and other components.

Most types of cavitation whether they are sheet, tip vortex cavitation, hub vortex or pressure face cavitation are evaluated during design and corrected at no additional cost for the customer.

Downstream propeller

Hydrodynamic forces and moments on the rudder can be monitored during the calculation, either in transit navigation or during manoeuvres. These forces and moments should be evaluated either with the rudder at 0 degrees angle or with small rudder angles as the ship spends most of its life navigating with small angle corrections due to the autopilot.

The rudder blade affects upstream the propeller, locally modifying the advance ratio (J), thus affecting its performance. Likewise, the rudder blade recovers part of the rotational energy of the propeller downstream. The profiles can be adapted to recover part of that energy, also applying solutions such as fins or bulbs. The CFD analysis of the forces and pressure fields in the different areas of the rudder allows to have a clear picture of the areas to improve.

Overall interaction

In summary, the propulsion of the ship is a complex system in which the interaction between the different parts is critical for a good result. Analysing each component individually results in suboptimal powertrains. A more technically complex but cost-effective solution, in comparison with the overall ship cost, is worth it for a successful project. *NA*

The inconvenient truth concerning shipping's steel corrosion

Increased focus on lowering maintenance cost and improving environmental performance has encouraged many stakeholders in the oil and gas industry to take a closer look at how coatings can extend the life-cycle of critical assets

Every second, five metric tonnes of steel degenerates, requiring 40% of all produced steel to repair and replace corroded structures [1]. According to a study released by the National Association of Corrosion Engineers (NACE), the cost of steel corrosion is estimated to be as much as US$2.5 trillion, which is equivalent to 3.4% of the global GDP [2]. Factoring in that every tonne of steel produced in 2018 emitted, on average, 1.85tonnes of CO_2 (representing about 8% of global CO_2 emissions), the environmental impact of replacing corroded steel represents a genuine sustainability challenge [3].

Corrosion Under Insulation (CUI) | Edge corrosion | Coating damages during construction | Early corrosion breakdown due to low DFT | Hot work damage | Surface contamination

Examples of common areas of premature corrosion

Many people once viewed coatings as a commodity, but opinions are changing. Recently, classification society DNV GL noted that coatings are the only cost-effective means to prevent atmospheric corrosion [4]. Research suggests that even a few hundred microns of the right product can have a significant financial and environmental impact by slowing or preventing corrosion.

Corrosion in the oil & gas industry

Coatings represent approximately 1.5% of the total CAPEX investment for an offshore production unit (FPSO). If not managed correctly, corrosion can represent as much as 60% of all maintenance cost directly or indirectly[5]. A high portion of the direct cost is due to performing maintenance in an offshore environment, which can be 15-20 times more expensive compared to a yard environment. In fact, a survey of operators has revealed that the average price of performing coating maintenance offshore is US$800-1,000 per m^2.

The topsides of a typical FPSO or production unit is a congested area and presents some unique challenges when coating maintenance is required. If not carried out correctly, a huge portion of money and effort can be wasted. It is therefore important to consider main factors that impact coating performance and durability:

- Surface contamination (e.g. oil, grease and salts)
- Presence of rust and mill scale
- Surface profile

When conducting maintenance, a commonly used KPI is how many square meters one can manage with their annual budget. However, this approach can result in a "false economy", as the focus is on efficiency rather than long-term performance, thus resulting in revisiting areas earlier than planned.

DNV GL estimates that 60% of the world's offshore fleet have past their theoretical design age of 20 years. New technology has enabled improved oil recovery (IOR), making existing oil fields economically viable, thus resulting in many older assets receiving lifetime extension programs.

Studying the condition of more mature production assets has revealed that the topsides areas exposed to atmospheric conditions are typically identified as the biggest challenge with corrosion. Common areas that see premature damage are:

- Edges on structural steel
- Pipe supports
- Corrosion Under Insulation (CUI)
- Deck areas
- Flange connections

Many of the premature failures originate from problems occurring during the new construction phase, where issues such as hot-work, mechanical damage and contamination of substrates have not been correctly addressed. In 2014, The Norwegian Oil & Gas Association concluded that units using zinc-based NORSOK systems for atmospheric exposure resulted in reduced maintenance and cost [7].

Summary

Experience illustrates a clear correlation between decisions made during construction and the operational cost (OPEX). Considering that as much as 60% of the maintenance cost can be related to corrosion, there is substantial potential for improvement.

Even projects that suffer premature corrosion challenges due to issues that occurred during the construction phase can still reduce the OPEX cost. Utilising coatings solutions that are more robust and designed to handle typical maintenance scenarios with a documented effect can significantly increase durability and lower maintenance cost, without compromising on efficiency.

It is clear that a large portion of manufactured steel is used to replace corroded steel. If so, the application of high performance coatings used for corrosion protection have the potential to provide a meaningful contribution not only to reduce costs, but also carbon emissions. *NA*

Cost reduction is just one potential benefit of utilising high performance coatings for corrosion protection

References

1) Rust & Råte, Journal; 2012 3rd edition
2) National Association of Corrosion Engineers (NACE); International measures of prevention, application and economics of corrosion technology study (March 2016)
3) McKinsey & Compan; Decarbonization challenge for steel, hydrogen as a solution in Europe
4) DNVGL-RP-C302, recommended practice for Risk based corrosion management
5) U. Steinmo and N. Heggelung, Norwegian oil review 1993.
6) Paolo Cavassi, Massimo Cornago, Roberto Malfanti; The cost of corrosion in the oil & gas industry
7) Norwegian Oil & Gas Association: FPSO & Shuttle Tanker Network, MoM 5th March 2014
8) The corrosion handbook by Nico Frankhuizen.published by TQC

The mystery of the first icebreaker

A lockdown investigation into the world's first icebreaker by RINA's Dmitriy Ponkratov and Jaime Pérez-Martínez turned into a detective story that led to the discovery of the ship's general arrangements

Figure 1: The first Arctic icebreaker *Ermack* (6MW) 1899

Some innovations live relatively short lives – they take off, make their contribution and disappear forever (who builds riveted ships with paddle wheels?). Other innovations persist across the ages and we know them well – diesel engines, propellers, radio communication – and normally we recall those brilliant pioneers who thought outside the box in creating something unique. Unfortunately, there are some exceptions…

Looking at the design of modern icebreakers, one can see that many changes have been introduced over the past decades: nuclear power engines, azimuth thrusters, welded steel, etc. However, it can also be noticed that the general hull form and traditional icebreaker bow shape remain ostensibly the same. But who was the first engineer (or perhaps not an engineer?) that had the bright idea of an innovative bow design capable of going through ice?

Newcastle upon Tyne, 1899

Hitherto, many believed it to be the famous Russian admiral Stepan Makarov, who initiated construction of the first Arctic icebreaker *Ermack* (Figure 1). This impressive vessel was built in Newcastle upon Tyne in 1899 and had the traditional icebreaker bow shape. Nevertheless, Makarov always denied being the originator of the idea.

Makarov wrote in his book *Ermack in Ice in 1901*: "The idea of icebreakers originated in Russia ... The first person who wanted to fight ice was entrepreneur Michail Britnev ... As you know, Kronstadt navy base is close to St Petersburg and is located on Kotlin island. In summer, communication was organised by boats, in winter by sleighs. But late Autumn and early Spring was the most problematic periods – because of moving ice in Finish gulf the base became literally isolated from the mainland.

So, an extended communication between the St Petersburg and Kronshadt base and delivery the post and goods would bring good money for an entrepreneur. And the man who challenged the natural limitations and spotted the opportunity was Britnev. In 1864, he put one of his boats, Pilot, in a dry dock, cut off the bow and attached the new one with a special shape capable to run into the ice and break it off. This little steamer did what seemed impossible: she extended the navigation time in the late fall by several weeks ..." [1].

Makarov also mentioned another interesting story: "In 1871 there was an extremely harsh winter in Europe; the entrance to Hamburg was frozen, and it was decided to build icebreakers. Engineers were sent to Kronstadt to watch the Britnev's vessel. They bought Pilot's drawings for 300 roubles, and, in accordance with these drawings, the first icebreaker was built for Hamburg..." [1].

The famous Russian historian Vladimir Andrienko made impressive research about the first icebreakers and published the book *Icebreaking fleet of Russia in 1860-1918* in 2009 [2]. Andrienko searched for any materials that Makarov might have used for his 1901 book. The admiral's archive is well preserved, but Andrienko could not find any references on where he took his material from. A few articles about icebreakers published in newspapers *The Kronstadt Bulletin* and *The Kotlin* at the end of the 19th century merely copy what Makarov said [3, 4].

St. Petersburg, 1860s

Due to the lack of archival materials, *The Kronstadt Bulletin* remains the main source for reconstructing the history of Britnev's steamboats. The systematisation and generalisation of newspaper publications over a 25-year period made by Andrienko, day by day, describing the voyages of private and port vessels in the Kronstadt region, allow us to better understand what was happening at that time.

Throughout the early 1860s, communication between Kronstadt, Petersburg and Oranienbaum was carried out by private wheeled steamers. In autumn, at the beginning of ice formation in the Gulf of Finland and on the Neva, direct connection with the capital usually ceased. After the formation of the ice cover, pedestrian and toboggan roads appeared on the mainland from the Merchant Harbour. During the period of freezing and ice drift the Kotlin was cut off from the mainland.

The first attempts to maintain communication between the island and Oranienbaum in the ice were made with the help of port steam vessel *Pilot* in 1862 and 1863. Judging by the later reports of the newspaper [5], no concrete successes were mentioned, except for rescue operations during navigation.

Mikhail Britnev, owner of barges, floating cranes and tugboats, decided to rebuild the *Pilot's* bow by copying the shape of the 'ice sleigh', previously used to make a channel in ice. His hope was that the combination of the special bow shape, together with the steam power plant and strength of the iron hull, would make it possible to ensure safe manoeuvres in ice. The first regular *Pilot* voyages in ice were reported for the first time in the spring of 1864, and advertisements of these voyages even appeared in the local newspapers [6]. So, from the spring of 1864 until 1889 (25 years!) when the new icebreaker *Luna* was delivered, the smaller *Pilot* remained an indispensable participant in the communication with Kronstadt in the ice.

Andrienko highlights in his book that it was not an easy service – *Pilot* fell into extreme situations almost every year, repeatedly rubbed in the ice, ran aground and hit ice pieces, but only the rudder, propeller and shaft suffered. The ship was quickly repaired and it returned to operations.

Of course, risky ice voyages brought considerable profit. A ticket for an ordinary paddle wheeled steamer to Oranienbaum cost 20-30 kopecks depending on the class (cabin, benches on the deck). Britnev's vessels were used mostly by private passengers (50-60 people on the deck per vessel), and the ticket cost 1–1.5 rubles.

Incidentally, Andrienko notes that Admiral Makarov's story of the creation of the first Hamburg icebreakers could not be confirmed by the documents, although it is known that the Hamburg port committee announced a tender in 1871 calling for proposals to create an icebreaker. There were 24 projects and that of an engineer named Mr Steinhaus won. The icebreaker designed by him, *Eisbreher I*, and all other German river and port icebreakers, had characteristics which were quite different to *Pilot* [7].

Andrienko also mentions that there are not many details about *Pilot*, and no one actually knows for certain what it looked like, since there was not a single reliable image or drawing of *Pilot*. The "icebreaker" shown on the Soviet postage stamp issued in 1976 is a repetition of the appearance of a nameless steam vessel (or steam barge), depicted in the painting by A.P. Bogolyubov "Opening of the Sea Canal in St. Petersburg".

Figure 2: Michail Britnev (1822-1889)

In the late 1950s, B. Zylev made a not very successful reconstruction of the *Pilot*: imagining it as a small tugboat with design features that could be attributed to the late 19th or early 20th centuries, but not to the 1860s-1870s (see Figure 6).

Andrienko also found a list of the vessels assigned to Kronstadt port dated the mid-1880s. The *Pilot* listed in this book has a deadweight of just 10tonnes, which seemed too small for this kind of ship. Was this a typo or it was another *Pilot*?

In 1896, Britnev provided the port of Kronstadt authorities with fairly detailed information about his *Pilot*: power – 25/125h.p. length – 20.7m, beam – 3.5m, draught – 2m. The steamboat's iron hull had 1/4 '(6.35mm) thick metal sheets, and the bow and waterline plating was 3/8' (9.52mm). The distance between frames was 2 feet (0.61m) [8]. This vessel was also in the List of River Steam Vessels of Russia (for 1897 and 1902) [9] but no further details have been found.

Figure 3: A Soviet postage stamp showing the possible look of *Pilot*. It should be noted that the vessel on the stamp has the Russian Navy flag which simply could not be allowed on commercial boats

Andrienko concludes in his book that despite the regular mention of *Pilot* in the Russian archives, this ship remains a mystery. So how might this historical vessel look like? Is there a chance we could ever find this out? By all appearances it seemed an impossible task (there is a Russian expression "searching for a needle in the stack of hay"). How many thousands of ships of this type must have been built over the last 160 years?

Nevertheless, an interesting detail was found in Vladimir's book. He stresses that it is not clear when and where the vessel was actually built, but he puts a line in a table that the steam engine was most probably built at Mitchell's factory in Newcastle upon Tyne.

Back to Newcastle, 1860's

Charles Mitchell, who was born in Aberdeen in 1820, founded the shipyard that bore his name in 1853. He served his apprenticeship with Simpson & Company, iron founders of Aberdeen, before moving to Newcastle in September of 1842. In Newcastle he worked for John HS Coutts, a yard owner, also originally from Aberdeen. Mitchell worked for Coutts until 1844 before moving to London and then travelling extensively in France, Germany and Italy. He returned to Newcastle in 1852 to set-up his own Low Walker yard next to the Coutts yard.

The yard built over 90 vessels of various types for Russia and Mitchell, together with his business partner Henry Frederick Swan, set up a shipbuilding yard for the Tsarist government at St Petersburg. Several warships were built there under the company's direction. In recognition of his services, Tsar Alexander II made Mitchell a Cavalier of the Order of St Stanislaus, a rare honour for a British shipbuilder.

Mitchell also had a close working relationship with engineer and industrialist William Armstrong, and Mitchell & Co built many hulls for Armstrong warships. Armstrong had established a company at Elswick in 1847 and had become one of the world's leading armament manufacturers. This close working relationship developed into a full agreed merger between the two companies in 1882, forming a new company called Armstrong, Mitchell & Co Ltd [10].

So, it seems Charles Mitchell had strong ties to Russia and, according to the records put together by Shipping & Shipbuilding Research Trust, the first vessels for Russia – *BRATETZ* "Little brother" (yard number 42) [12] and *SISTRITZA* "Little sister" (yard number 43) [13] – were built in Mitchell's yard in Newcastle in 1857. This came just a year after the Crimean War, during which the British and the Russian had actually fought against each other.

If nothing was found in Russian Archives about *Pilot*, there may be some track records in British archives then? A short line was discovered in the Shipping & Shipbuilding Research Trust records [14]:

Name:	*PILOT*
Type:	Pilot Vessel
Launched:	14/05/1862
Completed:	1862
Builder:	C Mitchell & Co
Yard:	Low Walker
Yard Number:	103
Dimensions:	23grt
Engines:	Steam
Construction:	Iron
Reg Number:	n/a

It sounded like a promising entry; however, the name *Pilot* is not an unusual one! Could we be sure we are talking about the same *Pilot*? Apparently so, because there are some further words in the registry book related to this entry:

History: 1862 MO Britneff, Cronstadt
No later history known

It's interesting to note that there were two ways of translating Russian names in Europe. The most common at the time was the French way (with double "f" at the end) and there are still residuals of that, e.g. Stroganoff, not Stroganov. Nevertheless, in Cyrillic both Britneff and Britnev mean absolutely the same, together with Cronstandt and Kronshatdt. So, there is little doubt that we are talking about the right Britnev and hence the right *Pilot*. That means we know the unique yard number of this vessel now: 103.

The authors reached out to the Tyne and Wear Archives, Newcastle upon Tyne, asking whether they had any information about Yard Number 103, completed at the Low Walker yard in 1862. Anyone would admire the British way of preserving history, for it transpired the archive had the vessel's General Arrangements in its collection (Fig. 7)! Remarkably, after 160 years, we can finally see what the first icebreaker looked like (Fig. 8).

Figure 4: Unconfirmed photograph of *Pilot*

Figure 5: Charles Mitchell (1820-1885) (11)

Conclusions

It is important to note that a discovery does not always lie in one place and sometimes it is important to bring a few pieces together to match the facts and find the missing link. So, the Tyne and Wear Archives kept the drawings for 160 years, assuming it was just an ordinary small steamer without knowing that it actually was the first icebreaker in the world. The Russian researchers, on the other hand, knew a lot about the vessel, but for some reason didn't make the connection with the British archives. Only bringing these two pieces together helped us to unearth an outstanding story.

One further observation. Bearing in mind the illustrious history of Russian arctic ships and as home of the world's largest icebreaker fleet to date, it's natural to imagine Russia as the motherland of icebreakers. Yet interesting to note that both the first icebreaker *Pilot* (1862) and the first arctic icebreaker *Ermack* (1899), despite being Russian ventures, were in fact built in English Shipyards.

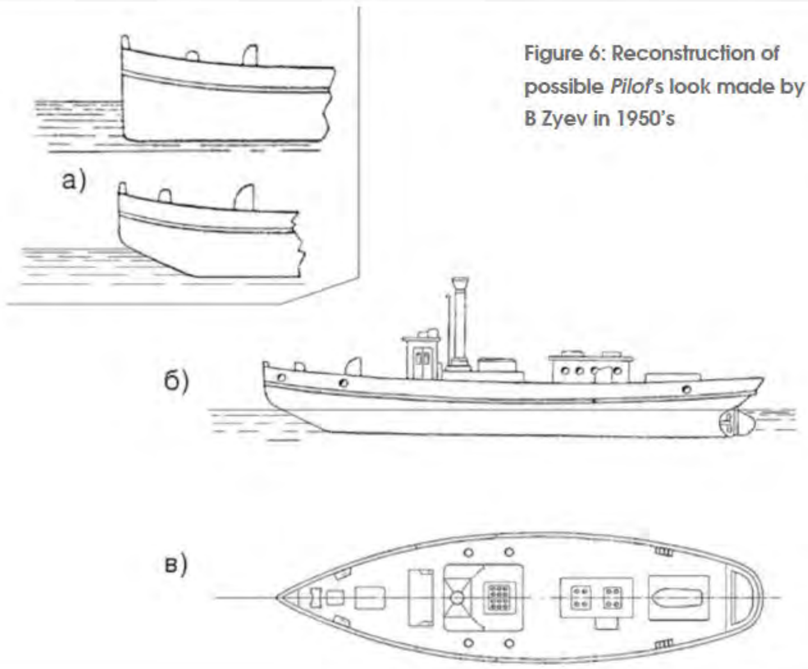


Figure 6: Reconstruction of possible *Pilot*'s look made by B Zyev in 1950's

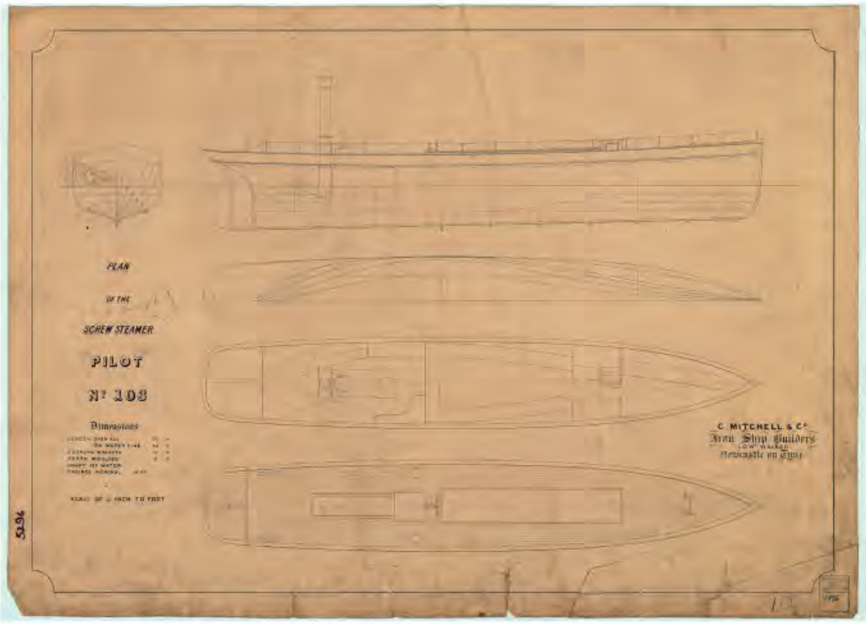


Figure 7: Plan of the screw steamer *Pilot*, Tyne and Wear Archives (15)

About the authors

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Jaime Pérez-Martínez holds the position of Technical Manager at the Royal Institution of Naval Architects. His previous experience includes project engineer at a repair shipyard in Gran Canaria and an engineering consultancy company in Madrid, as well as service in the Spanish Marine Infantry Corps. He is currently pursuing his PhD at the Universidad Politécnica de Madrid. *NA*

Figure 8: developed 3D model (with modified bow) based on the drawings

References

1. MAKAROV S, *Ermack in ice, St Petersburg*, 1901, reprinted in 2011, EKSMO publishing house.
2. ANDRIENKO V, *Icebreaking fleet of Russia 1860 – 1918*, Paulsen publishing house, 2009.
3. *The first Russian icebreaker*, The Kotlin, newspaper, 23 March 1899.
4. *The Kronstadt Bulletin*, newspaper, 28 May 1889.
5. *The first Russian Icebreaker*, The Kronstadt Bulletin, newspaper, 26 November 1872.
6. *The Kronstadt Bulletin*, newspaper, 14 April 1864.
7. YUDASHKE F, *Construction features of icebreakers*, Ree Dech Gafen yard, Jan 1929.
8. State Russian Navy Archive, f 427, ch.1, case 173, page 283.
9. *The list of steam river vessels of European Russia of 1900*, St Petersburg, Issue 4, 1902, pages 212-213.
10. Charles Mitchell, the Shipping & Shipbuilding Research Thrust, http://www.tynebuiltships.co.uk/Mitchell.html
11. Dr Charles Mitchell 1820-1895, Aberdeen's Links with Tyneside Shipbuilding, http://www.mcjazz.f2s.com/TynesideLink.htm
12. TYNE BUILT SHIPS, *A history of Tyne shipbuilders and the ships that they built, the Shipping & Shipbuilding Research Thrust* http://www.tynebuiltships.co.uk/B-Ships/bratetz1857.html
13. TYNE BUILT SHIPS, *A history of Tyne shipbuilders and the ships that they built, the Shipping & Shipbuilding Research Thrust* http://www.tynebuiltships.co.uk/S-Ships/sistritza1857.html
14. TYNE BUILT SHIPS, *A history of Tyne shipbuilders and the ships that they built, the Shipping & Shipbuilding Research Thrust* http://www.tynebuiltships.co.uk/P-Ships/pilot1862.html
15. Yard no. 103, Pilot. General arrangement 1862, Ref No DS.VA/4/PL/2/5296, Vickers Armstrong & Co Ltd Collection 1853 – 1971, Charles Mitchell (later Armstrong Mitchell) ship plans Section 1853 – 1907, Tyne and Wear Archives.

The evolution of marine propulsion machinery, 1840s-1990s

Data derived from the British Shipbuilding Database offers an insight into 150 years of technological progress, writes Ian Buxton

The evolution of marine propulsion machinery is well-known in qualitative terms, but not in quantitative terms. Statistical information is fragmentary and often inconsistent, so trends can be difficult to determine. The powerful British Shipbuilding Database,[1] involving 81,000 British built or engined ships over the past two centuries, now permits detailed analysis across a period during much of which the British marine engineering industry was the dominant force. This analysis is based on deep sea ships whose size, speed, power and endurance requirements drove most technical development, excluding smaller vessels, sailing ships and warships, for the decades from the 1840s-1990s.

The broad outline can be summarised:

- Coal-fired steam reciprocating machinery, initially paddle but soon superseded by screw in deep sea ships. Over the 1840-1950 period, thermal efficiency increased from about 4% to 20%, mainly due to higher boiler pressures and temperatures. Latterly, oil firing was used for most ships.
- Steam turbines for faster higher powered ships from 1900 to the mid-1970s, with either coal or oil-fired boilers. Initially for passenger vessels, followed by cargo liners, and finally tankers and early container ships. Thermal efficiency increased from about 15% to 35% over this period.
- Diesel engines from 1910 to date. At first, only low powers were available, but 30% thermal efficiency was a big attraction, albeit using oil which was more expensive than coal on a calorific value basis. The power of slow speed diesels had increased to over 20,000bhp by the 1960s, while thermal efficiency gradually increased to over 50%. Such capability pushed out all other prime movers except in a few niche applications and in warships.

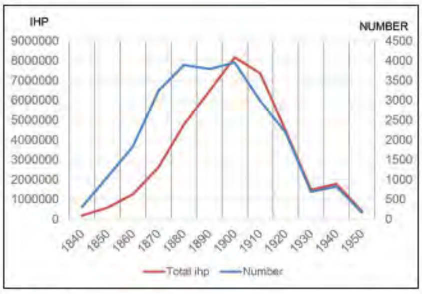

Fig 1. Merchant steam recip

Fig 2. Merchant steam recip

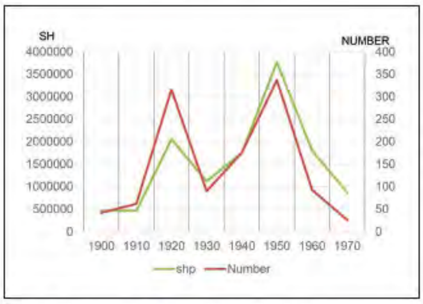

Fig 3. Steam Turbine Merchant Ships

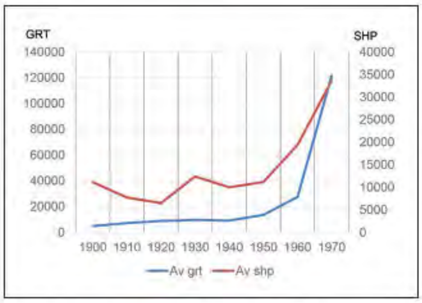

Fig 4. Steam Turbine Merchant Ships

The 1920s saw a battle between the three main prime movers, with many published papers extolling one or the other, but it took another half century for diesel to sweep the field. A further 50 years later, the internal combustion engine continues to dominate, now capable of using a variety of fuels.

While the analysis includes only British

Table 1. The evolution of shaft horsepower

	1840-1909			1910-1999		
	Number	Horsepower M	Av power	Number	Horsepower M	Av power
Steam reciprocating IHP	18,095	24.06	1,330	6,867	15.51	2,260
Steam turbine SHP	42	0.47	11,100	1,099	11.83	10,760
Diesels BHP				4,773	24.99	5,240
Total equivalent SHP	18,137	20.92		12,739	50.01	

[1]. The British Shipbuilding Database of 81,000 vessels is a work in progress but covers over 99% of eligible vessels, merchant and naval, with sufficient fields to generate consistent statistics on ship type, size, year and area of build, cost, fate etc. It is accessible in the Marine Technology Special Collection at Newcastle University or by contacting the compiler at ilbuxton@outlook.com

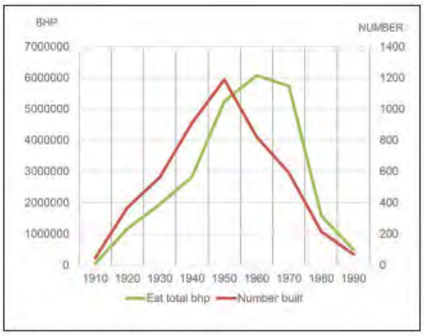

Fig 5. Diesel Merchant Ships

engined ships, these were representative of the world fleet for most of the period. But by 1990, British manufacture of prime movers for deep sea merchant ships had ceased, so the figures also chart the growth and decline of the country's marine engineering industry. Short sea and smaller vessels such as ferries, coasters, fishing vessels and service craft like tugs are omitted which, although numerous, made up only a modest proportion of installed power. Therefore, the graphs are based almost entirely on passenger vessels,

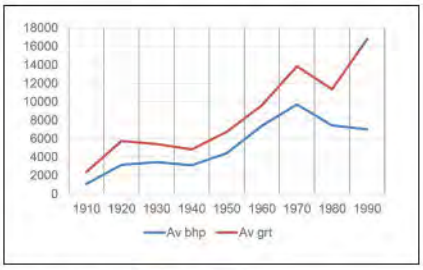

Fig 6. Diesel Merchant Ships

dry cargo ships and tankers, with the addition from the 1950s of bulk carriers and some specialist types like ro-ros.

For much of the 19th century, powers were usually recorded as nominal horsepower (nhp), a formula based largely on cylinder dimensions. But sufficient data on actual indicated horsepowers (ihp) exists to develop approximate conversion factors (varying from 2-6 ihp/nhp) and bring everything to a comparable basis. Brake and shaft hp are essentially similar for turbines and diesels, but in aggregating all types, shaft horsepower (shp) for steam

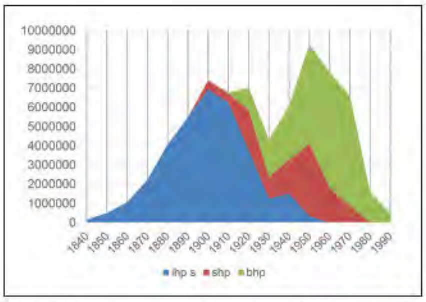

Fig 7. Horsepower of Merchant Ships

reciprocators has been taken as 85% of ihp. Thus, the combined sum comes to 30,876 ships totalling 71M equivalent shaft horsepower, averaging 193 ships per annum over 160 years. If warships were included that aggregate power nearly doubles, largely due to steam turbines.

Figs 1-6 summarise the three main machinery types in decade totals by number, gross tonnage and horsepower and with averages. Fig 7 shows the horsepower split: 47.4% steam recip, 17.3% steam turbine, 35.2% diesel. *NA*

Double doubts

Sir,

Due to Covid-19 and our poor postal service I have just received the September 2020 edition of *The Naval Architect* and read your interesting and stimulating Editorial.

Although certainly not the single biggest change in naval architecture and ship construction, I am of the opinion that one of the worst decisions made during the past 30 years was that which required oil tankers to have double hulls. This, as I understand it, requires a tanker of, say, 150,000tonnes, to be effectively put inside a larger vessel requiring more steel for its construction, more metres of welding, and a larger engine in order to maintain the same service speed. This engine would require more fuel and create more exhaust gas in order to achieve the same service speed as a single-hulled tanker of the same deadweight capacity.

According to Wikipedia the enquiry into the grounding of *Exxon Valdez*, which gave rise the decision to introduce double-hulled tankers, found that a double hull would not have prevented an oil spill but would have reduced the amount spilled so it does have some advantage.

Exxon Valdez

The regulations seem to have produced a tanker which costs more to build, costs more to operate due to increased fuel consumption and is not really much safer than a single-hulled tanker built pre 1990. In addition, at the end of its life the double-hulled tanker will require the combustion of more acetylene for demolition than a single-hulled ship of the same capacity, adding unnecessarily to global warming.

Despite the naval architect's greatest efforts it will not be possible to design a ship which will not sustain damage in a collision or grounding. It is far better to concentrate on avoiding these events by training and motivating seagoing personnel to do their jobs well and ensuring that ships are properly manned so that those responsible for navigating them are not too fatigued to do their jobs properly.

It's just a thought.

Yours sincerely,

W. H Rice BSc; F Saimena; MRINA,
Captain S A Navy (Retired)
Republic of South Africa

Challenging the disconnects

Sir,

Readers may have seen my series of articles concerning structural issues with bulk carriers (see *TNA* October 2019, January and June 2020, January 2021). I do not attempt to claim any priority of attention for the specialised bulk carrier topic but I do wish to point out that the principal motivation behind my efforts is the safety of the seafarers manning these ships and indeed the efficient delivery of their cargoes. I need to make clear that by bulk carriers I am referring to vessels with large holds bounded by triangular section topside tanks and lower hoppers with double bottoms beneath all holds. These ships should not be confused with ore carriers that have small holds set into much larger tanks and voids more similar to the old style of tanker (before double hulls).

Following some response from readers, in particular concerning the topic of flexibility of the hulls in question, it seems appropriate to add to the original content. As a superintendent I noticed that, as the displacements grew from the old Panamax circa 80,000dwt to Capesize circa 180,000dwt with a few topping the 200,000dwt mark, lightweights did not escalate in the same proportion to their displacement. We were therefore not surprised when masters began reporting excessive flexing in the hulls and seeking reassurance about their decisions to slow down.

We were also told by shipbuilders, verified by class, that higher tensile steels allowed for reduced thickness of the shell plating and other structural elements. We noted however that high tensile and mild steels corrode at about the same rate, which presumably means that with reduced thickness the section modulus in a high tensile hull reduces proportionately faster than in one built of mild steel. Does their increased flexibility also accelerate fatigue? Are these unintended consequences we often hear about after mishaps?

I was encouraged therefore to hear from Nicolas Bialystocki – an engineer practising draught survey in the real world and author of an excellent paper in the October 2020 issue of *TNA* suggesting a need for reassessing draught surveys in large ships. His observations fit well with those I made of double deflection in the 1990s when we were first experiencing gauging discrepancies of up to 1,200tonnes and which prompted the company to order quarter length draught marks on newbuilds. The depressing part was trying to alert the ultra-conservative survey sector to the phenomenon and to adapt their calculation methods. They never would for us. I hope Nicolas' article engenders a better response.

The point of this letter however is to emphasise the value of real-world observations and to challenge academia to integrating such observations into research. I worry when I hear academics utter the words "there is no evidence …" before responding to questions about something inconclusive. It may be true in as much as there has been no scientifically controlled research but evidence can be found if one looks for it. Before retirement I was an accident investigator and I know that the devil really is in the detail. If information does not meet the standards required of academic research it should stimulate the need for such research. To do otherwise is to adopt the language of politicians when they need to deflect attention from omissions in their own knowledge. Although in political (and some bureaucratic) circles it might be regarded as a sign of weakness to admit to incomplete knowledge the same should not be so for the scientific community who surely have a duty to continue seeking out more certainty.

The objects of RINA are set out in the Charter of Incorporation, namely –"the improvement of ships and all that specially appertains to them, …"

This suggests that when learning of something unexplained it should be incumbent on RINA as an Institution to look further into it. To dismiss the anecdotes of professionals with decades of experience in service is neither courteous nor aligned with the objects stated above. I am encouraged at the responses I have received but I am also aware of many areas of disconnect between design, management, operation and regulation – not least the variations in language used by each sector. Perhaps we should be striving to challenge these disconnects.

Dennis Barber,
Master Mariner. FNI. FRINA. MRIN
United Kingdom

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