THE NAVAL ARCHITECT

A publication of The Royal Institution of Naval Architects | www.rina.org.uk/tna

Safety / South Korea / LNG/LPG / Netherlands / CAD/CAM / **October 2019**

NAVALIA

INTERNATIONAL SHIPBUILDING EXHIBITION

Sponsors:

ABANCA · DNV·GL · FERNÁNDEZ JOVE · REPSOL · Sika · WIRESA · VULKAN

CONCELLO DE VIGO · XUNTA DE GALICIA · igape · Puerto de Vigo · ZONA FRANCA VIGO · IFEVI

Organised by:

muéstralo

Editor: Richard Halfhide
Editorial Assistant: Kaylee Maddison
Production Manager: Nicola Stuart
Advertisement Production Manager: Stephen Bell
Subscriptions & Publications Manager: Tasharna Francis
Publisher: Dmitriy Ponkratov

Advertising Sales: J P Media Services
Email advertising: jpayten@jpmediaservices.com
Telephone: +44 (0)1737 852135

Published by:
The Royal Institution of Naval Architects
Editorial Office:
8-9 Northumberland Street
London, WC2N 5DA, UK
Telephone: +44 (0) 20 7235 4622
Telefax: +44 (0) 20 7245 6959
E-mail editorial: editorial@rina.org.uk
E-mail production: production@rina.org.uk
E-mail subscriptions: subscriptions@rina.org.uk

Printed in Wales by Stephens & George Magazines.

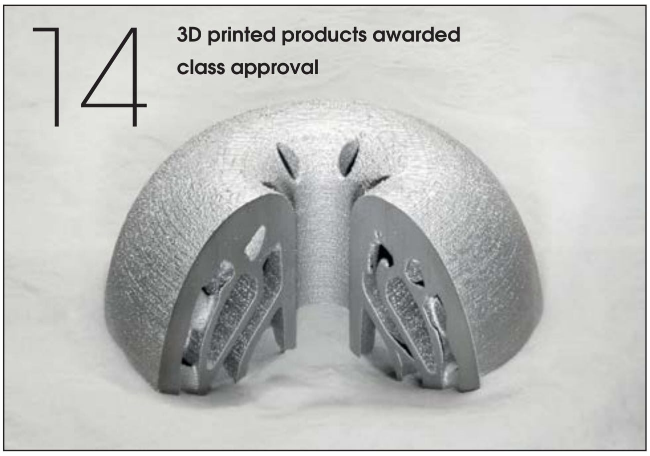
A 2019 subscription to *The Naval Architect* costs:

NAVAL ARCHITECT (10 issues per year)

12 months	Print only†	Digital Only*	Print + Digital
UK	£196	£196	£250
Rest of Europe	£205	£196	£258
Rest of World	£220	£196	£274

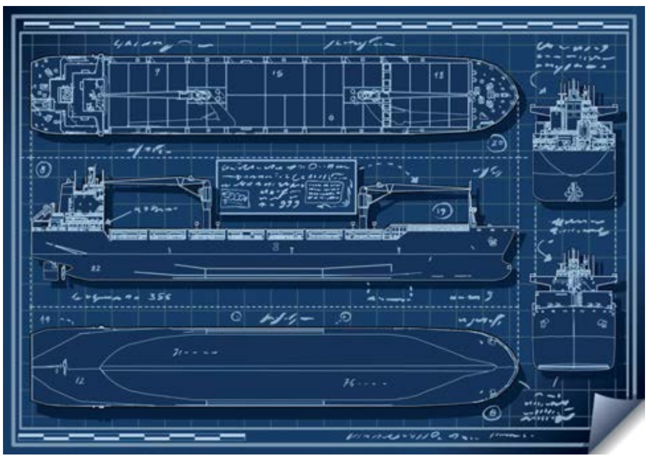
†Incudes p+p
*Inclusive of VAT

The Naval Architect Group (English Edition)
Average Net Circulation 10,291 (total)
1 January to 31 December 2018
ISSN 0306 0209



14 3D printed products awarded class approval

43 Clarifying contract plan confusion




KORMARINE
2019
International Marine, Shipbuilding, Offshore, Oil & Gas Exhibition
OCT 22(TUE) - 25(FRI), BEXCO, BUSAN, KOREA
MARINE
SHIPBUILDING
2019 SPECIAL ZONE (GREENSHIP & LNG)
OFFSHORE
OIL&GAS
982 EXHIBITORS
38,034 SQM SHOW SCALE
46 COUNTRIES
83% REBOOKING
*Statistics of KORMARINE 2017
ORGANIZED BY. REED K. FAIRS LTD. TEL +82-(0)2-554-3010 E-MAIL daeun.kim@reedkfairs.com www.kormarine.com
Ministry of Trade, Industry and Energy
BUSAN METROPOLITAN CITY
KOSHIPA
KOMEA Korea Marine Equipment Association
Reed K. Fairs Exhibitions

18-42 Features

22 Enhancing mass evacuation with Seahaven

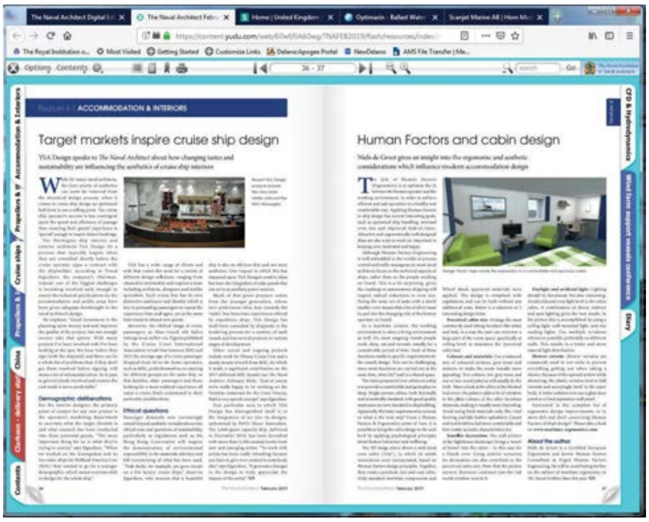
33 Bolidt introduces innovation hub for co-creation

40 Entering new realms of design through Virtual Reality

Digital Editions

The Naval Architect is published in print and digital editions. The current and archived digital editions may be read on PC, iPad or other touchpad.

Visit http: www//rina.org.uk/Naval-architect-digital.html to read the digital editions, or download the free RINA Publications App.



YOU'RE INVITED!

HOMEPORT OF THE LEISURE MARINE COMMUNITY

19 - 20 - 21
NOVEMBER 2019
RAI AMSTERDAM
THE NETHERLANDS

The Metstrade Show is the happening meeting place in Amsterdam where the international leisure marine community gathers. In a hospitable environment, we make you feel at home to meet and mingle with the entire industry. Feel connected and charge yourself to optimise your business.

METSTRADE FEATURES

SYP SUPER YACHT PAVILION

MYP MARINA & YARD PAVILION

CMP CONSTRUCTION MATERIAL PAVILION

ORGANISED BY rai AMSTERDAM

POWERED BY ICOMIA

MEMBER OF IFBSO

OFFICIAL METSTRADE MAGAZINE IBI

OFFICIAL SYP MAGAZINE The Superyacht Report

OFFICIAL MYP MAGAZINE Marina World

METSTRADE.COM

IRClass takes the chair

Arun Sharma, IACS chairman and CEO of IRClass

A few days ahead of London International Shipping Week (LISW) in September, the International Association of Classification Societies (IACS) held a press conference to formally introduce its new chairman: Arun Sharma, executive chairman of the Indian Register of Shipping (IRClass).

IRClass is both RINA's youngest member (it was only formed in 1975) and the first of its 'new' members (having only become a full member in 2010) to be elected to the chair. In that regard, it might be said to be finally drawing a line under the antitrust allegations of more than a decade ago, an episode that saw IACS accused of being run as a cartel and reducing competition in the ship classification market. Since that time the Association has been committed to uniform and qualitative membership criteria, as well as putting all resolutions and technical documents into the public domain.

Because the IACS chair rotates annually, it's often difficult to determine whether the incumbent's role is anything other than symbolic. Sharma's predecessor, Jeong-kie Lee of the Korean Register (KR), was comparatively quiet during his tenure, having only taken over as KR's CEO a few months before. By contrast, the preceding chairing by Knut Ørbeck-Nilssen of DNV GL heavily promoted IACS initiatives with regard to issues such as autonomous ships and cyber resilience.

What's clear, however, is that the industry is increasingly turning to class societies for advice on how best to tackle the current and emerging challenges. Left to their own devices most shipowners would prefer to fudge and obfuscate on making major decisions, not because they're not concerned about the state of the world but that making the wrong decision could have ruinous implications in current trading conditions.

Sharma acknowledged this, saying: "Primarily the role of class will remain what it was 250 years ago; the protection of life and assets at sea and on land, and more recently the environment… But of late the industry looks at class beyond just implementing regulations. Class today is willing to provide solutions to shipowners and that role will probably have to grow with the rapid technology changes and need for more efficient ships."

Presenting an overview of the current state of the industry, Sharma advocated slow steaming as the best means of achieving the 2030 target of a 40% reduction in CO_2 emissions. But he warned that this and other efficiency improvements are no more than "bolt-ons", and the great leap forward will still need to be delivered by alternative fuels.

He added that the drive towards decarbonisation would have profound implications for every aspect of maritime in ways that weren't yet being discussed; for example, demand for larger bulkers and tankers will fall steeply with less trade in coal and crude. Conversely, the imminent sulphur cap could bring a short-term boost to shipbuilding if, as some predict, the high cost of low-sulphur fuel compels operators to adopt lower speeds and higher freight rates.

As IMO's principal technical advisor, IACS is central in supporting its decarbonisation and desulphurisation initiatives; whether as a conduit with shipowners and shipbuilders, in assisting IMO's Data Collection Scheme for emission and fuel consumption, and ultimately in validating new fuel technologies. Beneath that there's also the subtext of ensuring its members are singing from the same hymn sheet and that technical support, compliance verification and classification standards are applied consistently.

Whether that is always the case sometimes been open to question. Pointedly perhaps, one of its focuses for this year will be on continuous improvement and the setting of internal benchmarks for those members. For all that the Association likes to emphasise it has adopted transparency as its mantra, there remains some coyness when it comes to illuminating what forms of reprimand are in place for underperforming members.

India, as has been commented upon in this magazine only recently, has yet to accede to IMO's Hong Kong Convention on Ship Recycling (HKC). IRClass, it should be stressed, was among the earliest class societies to be certified as an independent verifier to European Union Ship Recycling Regulation standards and is undoubtedly assisting the Indian government in implementing legislation consistent with HKC requirements. However, it does illustrate the challenges of being inclusive and sympathetic to socio-economic realities while ensuring IACS remains a badge of quality.

Moreover, pluralism perhaps also allows the Association a deeper insight into just what's at stake. "This year, Mumbai has experienced intense rains not seen for time immemorial. The same thing happened to Chennai two years ago," reflected Sharma. "Climate change is becoming so visible and devastating that to call it frightening is an understatement. Emission reduction is going to be the focus area for IACS in 2019-20 and I'm sure for every chair in the future until the IMO GHG ambitions are achieved." *NA*

Emissions control

Investment needed in sustainable technologies, warns Lim

International Maritime Organization (IMO) Secretary-General Kitack Lim used London International Shipping Week to herald a "propulsion revolution" being driven by IMO's GHG targets.

Speaking to delegates at the International Chamber of Shipping's (ICS) 2019 conference, 'Setting the Course for 2050', on 11 September, Lim said there were strong signs emerging that some sectors are grasping the urgency of making zero-carbon ships attractive to investors. But he encouraged industry bodies to co-operate further with member states in strengthening regulations.

"Battery powered and hybrid ferries, ships trialling biofuels or hydrogen fuel cells, wind-assisted propulsion and several other ideas are now being actively explored. The IMO GHG strategy has sent a clear strategy to innovators this this is the way forward. However, actions need to be accelerated if its goals are to be achieved," said Lim.

He added that progress over the next decade would be crucial, but in the short-term IMO would consider concrete measures for improving the operation efficiency of existing ships, cutting methane slip and providing support to the GHG action plans of national administrations.

With regard to the more immediate challenge of the sulphur cap, Lim highlighted the efforts that IMO, member states and the shipping and bunker supply industry had made to support its implementation. "I am confident that the implementation date on 1 January 2020 will be managed smoothly," he concluded.

Kitack Lim, IMO Secetary-General

Containerships

Evergreen spends big on boxships

Taiwan-based operator Evergreen Shipping announced plans in September to buy 10 containerships of 23,000TEU from shipyards in South Korea and China, with a combined value of up to US$1.6 billion.

The news follows an upscaling of investment plans Evergreen announced only a month earlier, when it said it would build six ships and charter five. Samsung Heavy Industries (SHI) will build six of the new vessels, while Jiangnan Shipyard and CSSC-owned Zhonghua Shipbuilding will each build two.

One of the world's largest cargo lines, Evergreen has seen fluctuating fortunes in recent year. After reporting losses of US$126 million and US$246 million in 2015 and 2016 respectively, it then reported profits of US$120 million in 2017. However, in 2018 this fell sharply to just US$21.2 million.

Undoubtedly, the operator feels it is under growing pressure to keep pace with its rivals. In July, Mediterranean Shipping Company (MSC) again broke the record for the world's largest containership when the 23,756TEU *MSC Gulsan* was delivered by SHI. In total, MSC has 11 vessels in the 23,000TEU bracket due for delivery by the end of next year.

Meanwhile, Hyundai Merchant Marine last year placed an order for 20 very large containerships, including 12 in the 23,000TEU range, that will start entering operation in the second quarter of 2020.

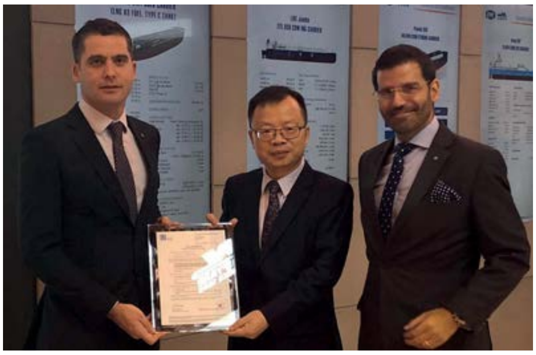
However, there remains grave concerns about the impact these megaships will have on overcapacity in the sector, which had recently shown signs of stabilising. The ongoing trade dispute between the US and China, as well as a Brexit-influenced slowdown on European trade, are doing little to allay fears of a slowdown in the global economy.

Gas carriers

LR announces AiPs for VLGC and VLEC at Gastech

Lloyd's Register (LR) used the Gastech 2019 trade show in Houston in September to announce the Approval in Principle (AiP) for several design concepts.

Jiangnan Shipyard (Group) Co of China was awarded an AiP for its Panda 91T design, a 91,000m^3 very large gas carrier (VLGC). Comprising of an LPG-fuelled main engine and fuel gas system, the design is said to offer an Energy Efficiency Design Index (EEDI) value of 40% lower than the base value



LR awards Jiangnan Shipyard its VLGC AiP

and comes with an optional air lubrication system.

LR's services were of particular importance in the development of the LPG fuel gas system and related technology, for which it facilitated a hazard identification (HAZID) workshop. The initiative is part of the classification society's ShipRight Procedure for Risk-Based Designs, intended to ensure compliance with both its own rules and international regulations concerning the carriage of liquified gases and low-flashpoint fuels.

Jiangnan Shipyard has already secured seven contracts for its similar Panda 86P design this year, but mindful of the gas trade between North America and China, felt that additional fuel capacity was needed for long-distance routes while optimising the ship's dimensions.

Meanwhile, South Korea's Daewoo Shipbuilding & Marine Engineering Co (DSME) has been granted an AiP for its 98,000m^3 very large ethane carrier (VLEC). The design is the first to use a new cryogenic material, High Manganese Austenitic steel (High MnA), the application of which was approved at the 100th session of IMO's Maritime Safety Committee in December last year. It also incorporates DSME's patented 'Type B' sloshing-free tank, allowing the vessel to operate with partial loading and multi-port scenarios. This flexibility further extends to its potential to carry a variety of different cargoes, be it LNG ethane/ethylene, propane or butane.

In addition to conducting structural design, sloshing and scantling assessments in accordance with ShipRight, LR appraised the miship section, construction profile and shell expansion drawing of the VLEC to ensure compliance against its prescriptive rules.

Employment

High prospects for naval architecture graduates

Naval architecture and marine engineering has been ranked as the most valuable university major according to Bankrate, a US-based personal finance site.

Those with a degree in naval architecture and marine engineering earned a median annual income of US$90,000 and an unemployment rate of only 1.6%. In comparison, all other majors had a median annual income of US$55,000 and a 2.8% unemployment rate.

Of the 162 university majors Bankrate ranked, it found that although naval architecture graduates might not end up earning the most, they have the best chance of earning a strong and steady salary. The degree topped other science and engineering degrees such as genetics, nuclear and electrical engineering.

Those trained to build, design and maintain ships were also likely to have an easy time landing a job after graduation. The Bureau of Labour Statistics predicts that employment of naval architects and marine engineers will increase 12% from 2016 to 2026, thanks to the growing demand for environmentally friendly ships.

To determine the most beneficial bachelor's degree, Bankrate analysed data from the 2017 US Census. It also considered how many people in each group went on to obtain a higher degree while factoring in the additional cost of extra schooling.

Shipbuilding

Canada backs plans for world's first low-noise tanker

Vancouver-based Teekay Shipping has partnered with the Government of Canada to develop the world's first low-noise and low-emissions tanker.

The Agreement in Principle (AiP) will see the government and tank operator design an LNG-fuelled crude oil tanker fitted with state-of-the-art quiet technologies. By employing the best available equipment and operational practices, the vessel will reduce noise by 90% and GHG emissions by 20%, compared to conventional tankers.

Facilitated through the Quiet Vessel Initiative, the government has agreed to invest up to CND$30 million (US$22.5 million) to support the project. The initiative aims to reduce underwater noise in order to help protect the marine environment and species, including the Southern Resident killer whale which resides near Vancouver.

The impact ships have on whales and marine animals is a topic of increasing concern. Acoustic disturbances produced by vessels threaten whale's ability to find prey, effectively navigate, and communicate with each other.

Other measures to cut ship noise and protect Canada's coast and waterways, such as the Vancouver Fraser Port Authority's EcoAction Program (see *The Naval Architect*, March 2019), were launched in 2017, making it the first country to encourage silent ships. *NA*

Shipping debate and a UK shipbuilding renaissance at LISW

The maritime community convened in London for a multifaceted programme of events, writes Malcolm Latarche

Unlike most of Europe's other big annual or biennial marine events such as SMM and Norshipping, London International Shipping Week (LISW) is not so much a celebration of equipment and marine technology as a talking shop based around shipping rather than ships themselves.

When the countdown to the 2019 LISW began last September, the chosen theme was International Trade in a Changing World. At the time it was expected that Brexit would have happened and the UK would no longer be part of the EU. However, events have not turned out as expected and London in September has been in something of political turmoil with the new Boris Johnson minority government fighting on a number of fronts.

As far as international trade goes, the world is most definitely changing. A tariff war between the US and China looks likely to lead to a global slowdown, and US and EU sanctions on Iran have seen tit-for-tat seizures of oil tankers. These two topics alone provided plenty of debating opportunities for those bodies taking part in LISW.

For the more technical aspects of shipping, it is the impact of the 2020 global sulphur cap change that is causing the biggest headache, and that – coupled with the IMO's decarbonisation plans – provided a major conversation subject for the various seminars, presentations and events that made up LISW 2019.

Arguably, the headline event for the changing environment for power and propulsion was the International Chamber of Shipping's (ICS) 2019 Conference – Setting Course for 2050: Powering Global Trade. Speakers included the Rt. Hon. Nusrat Ghani MP, Parliamentary Under Secretary of State for Maritime, Department for Transport; Kitack Lim, Secretary-General, IMO, The Rt. Hon. The Lord Turner of Ecchinswell, Chair, Energy Transitions Commission, Dr Rhian-Mari Thomas OBE, CEO of the Green Finance Institute and numerous others from inside the shipping industry.

In his opening remarks on behalf of the ICS, Emanuele Grimaldi, managing director of Grimaldi Group, reflected on the challenge ahead and the ground-breaking agreement on CO_2 emissions concluded in April last year, known as 'The Paris Agreement for Shipping' and said: "It represents a fundamental transformation in the business of shipping, something that we at ICS call the Fourth Propulsion Revolution."

Grimaldi went on to say: "What is also clear is that we can't do it alone. Without the support of consumers, policymakers, the finance community and suppliers the Fourth Propulsion Revolution will be stifled. We must all work together to mitigate the risk of transformation. Risk is our common language. And we need to reach beyond our own community to ensure that the risk is equitably allocated and priced."

Grimaldi's remarks highlight the fact that despite all the regulators best intentions and the lobbying from environmentalists, shipowners by themselves cannot change the choice of technologies available. That is something that most technically minded observers understand and until the technology is mature enough to enable a vessel to operate reliably in mid-ocean there is no chance that shipowners will install fuel cells or the other supposed solutions that some industry critics advocate.

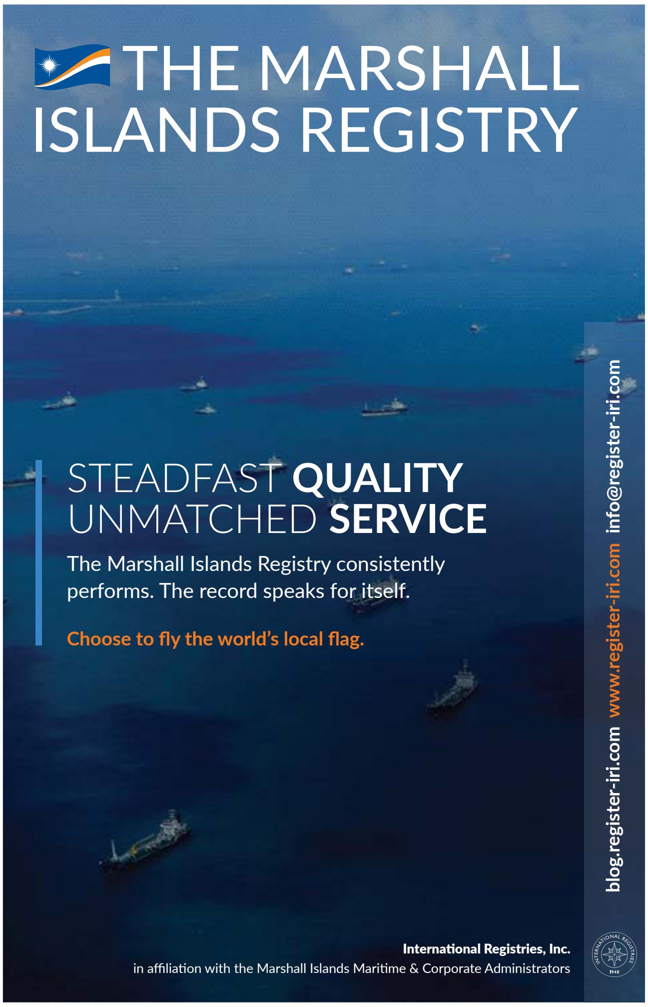
The packed agenda covered climate science, research and development, finance, policy instruments and the role of the Global Maritime Value Chain.

At a different event the ICS was joined by BIMCO, Intertanko and Intercargo meeting as the Round Table and discussing the impending implementation of the 2020 sulphur cap. The participants called on all parties, including charterers, bunker suppliers and nation states to double their efforts to ensure a smooth transition. The Round Table leaders also reiterated the urgent need for fuel standards to be put in place ahead of 1 January 2020.

Highlighting the concerns of many shipowners. Dimitris Fafalios, chair of Intercargo who also chaired the meeting, said: "The industry has been working hard to ensure that we are ready for 1 January 2020 but we still have major concerns over safety and availability of compliant fuels. We need all parties to fully play their part, it would not be acceptable to have even one ship drifting powerless at the mercy of the ocean."

On a national level, LISW came at an opportune time for British shipbuilding with the government announcing plans to revitalise an industry that has been in decline for decades. Following the announcement, it was revealed that a consortium led by Babcock and including the builder of the *Titanic* – Belfast's Harland and Wolff shipyard – would likely be awarded a contract for new naval vessels later this year. The contract is for five frigates that will be assembled at Babcock's Rosyth Dockyard in Fife and will involve supply chains throughout the UK. Among the thousands of jobs expected to be supported by the programme are 150 positions for new technical apprenticeships. *NA*

Veth Integrated L-drive
The most compact thruster ever
Extremely low mounting requirements, high efficiency, minimal noise production
DAME
SPECIAL MENTION
2018
T +3178 615 22 66
www.vethpropulsion.com
VETH
PROPULSION
BY TWIN DISC



THE MARSHALL ISLANDS REGISTRY
STEADFAST QUALITY
UNMATCHED SERVICE
The Marshall Islands Registry consistently performs. The record speaks for itself.
Choose to fly the world's local flag.
International Registries, Inc.
in affiliation with the Marshall Islands Maritime & Corporate Administrators
blog.register-iri.com www.register-iri.com info@register-iri.com

creating seaworthy software
Stability & Strength Assessment
Cargo Management & Load Planning
Ship Design & Production
World-Wide Service & Support
www.autoship.com
Why go anywhere else?
autoship.com

Lubricants

Castrol refocuses engine room operations debate

Shipowners need to approach engine operations from a holistic point of view and give equal consideration to hardware, lubricant and fuels to ensure a smooth transition into 2020, according to Castrol.

With the fast approach of IMO's 0.5% global sulphur cap, the lubricant manufacturer is pushing for the industry to refocus its outlook in order to prepare for the impact new compliant fuels will have on engine room operations. New fuels are becoming a critical concern for operators and can lead – if not managed properly – to loss of engine power and propulsion, resulting in potentially severe damage to engines and consequential financial implications for shipowners, operators and charterers.

The company states that it is vital to anticipate many of the future outcomes of the transition for engine hardware, lubricants and fuels, with a collaborative mindset that incorporates key partners such as engine manufacturers, fuel suppliers and customers.

"The industry must reframe the 2020 debate to look at the full picture of engine health, to help ensure compliance is implemented and managed smoothly, and that we are ready for the challenges of a changing world," Cassandra Higham, head of Marketing of Global Marine and Energy at Castrol, tells *The Naval Architect*.

The question of lubricant choice has become considerably more difficult, for example, with new attributes and qualities demanded of engine fluids than at any point in the past. Yet, some of the greatest challenges remain 'known unknowns'.

"It is also important that we look beyond 2020 to consider the long-term effects of the IMO's new regulations, as well as the ramifications of forthcoming rules around NOx and decarbonisation," says Higham.

Propulsion

ABB to fit bulk carriers with Azipod units

Swiss-Swedish engineering giant ABB has broken into a new market segment with an order to install its Azipod electric propulsion system on two dry bulk carriers.

The self-unloading cargo vessels, owned by Germany-based Oldendorff Carrier, will be the first bulk carriers to feature ABB's electric propulsion units. Under construction at Chengxi Shipyard in China, the 21,500DWT transshipment carriers are expected for delivery in 2021.

Each vessel will be fitted with two 1.9MW Azipod units along with a range of electric, connected and digital solutions supplied by ABB. The complete power and propulsion system will include a main diesel-electric power plant, generator, bow thruster motors, transformers, switchboards and power management system for propulsion and cargo handling.

Oldendorff Carriers, Germany's largest bulk carrier company, designed and developed the newbuilds together with the Shanghai-based CS Marine. Once completed, the vessels will join the company's fleet of 700 ships, 95% of which is comprised of 'eco' newbuilds that have been gradually entering service since 2014.

To date, Azipod units have been installed on approximately 25 vessels. The system, which is driven by an electric motor submerged in a pod located outside the ship hull, is capable of rotating 360 degrees.

Additive manufacturing

3D printing manufacturer gains first approval

DNV GL has awarded Thyssenkrupp Marine System a certificate of approval for its metallic 3D printed products.

This marks the first time the Norway-based class society has awarded a producer of 3D printed parts for maritime applications with manufacturer approval. The certificate deems that production and processing of its austenitic stainless steel parts, which can be integrated on ships and submarines, are quality assured. As a result, parts users can trust an additive manufactured product as they would a conventionally produced one.

The 3D manufacturing process was developed by the German industrial group Thyssenkrupp in collaboration with Thyssenkrupp TechCentre Additive Manufacturing. The company sought certification after identifying a need for parts with acceptance certification and aims to further integrate additive manufacturing into its maritime business.

By utilising 3D manufacturing, it is expected that lead times, costs and required stock will be notably reduced, thereby impacting the overall maritime value chain.

Thyssenkrupp's 3D printed parts are now certified for maritime use (Courtesy: Thyssenkrupp)

DNV GL published its initial guidelines for additive manufacturing in 2017, outlining the potential shift in the maritime industry. It carried out extensive tests and examinations of Thyssenkrupp TechCentre, which became operational in 2017, in order to determine its reliability and standards.

Cargo systems

MacGregor outfits megaship with optimised cargo system

Cargotec's MacGregor has designed a specialised cargo system for the *MSC Gülsün*, the world's largest containership.

Delivered in July 2019 by South Korea's Samsung Heavy Industries, the vessel is the first in a series of 11 ultra-large containerships with a capacity over 23,000TEU. Measuring 400m long, 61.5m wide, the *MSC Gülsün* beat the megaship record set by the *OOCL Hong Kong*, the first vessel to break beyond 21,000TEU.

The cargo system was developed by MacGregor in collaboration with Mediterranean Shipping Company (MSC) from an early stage in the project. The cargo design, in combination with a 24-container wide ship design, ups the *MSC Gülsün*'s total capacity to 23,756TEU – 1,500TEUs more than the largest containerships have previously carried.

To maximise the ship's performance, the system balances MSC's operational requirements with the ship's cargo intake while providing flexibility for the cargo operations and planning process.

Orders for the vessels were booked during 2018 and the first quarter of 2019. Earlier this year, MSC signed a contract with MacGregor and Guangzhou Wenchong Dockyard to upgrade cargo systems on six of the company's 16,000TEU containerships. Those upgrades will be carried out in 2020.

Paints

Hempel launches new fuel-saving coating system

Denmark-based coatings manufacturer, Hempel, has introduced a new three-layer fouling defence system with a low Average Hull Roughness (AHR) to help shipowners cut emissions and improve efficiency.

Dubbed Hempaguard MaX, the antifouling system is said to reduce drag and deliver a guaranteed maximum speed loss of 1.2% over five years. As a result, vessels will require a lower fuel intake.

The coating is made up of three-layers: Hempaprime Immerse 900, tie-coat Nexus II, and Hempaguard X8. Hempguard X8 uses Actiguard technology to drive the system's antifouling performance while Hempaprime Immerse 900 and tie-coat Nexus II contribute to its low AHR.

According to the company, Hempaguard MaX can be applied faster than other systems, reducing dry docking time by up to two days. Between the increased fuel saving and shorter drydocking times, Hempel claims a payback period within three months (based on a VLCC with an activity level of 70%).

Engines

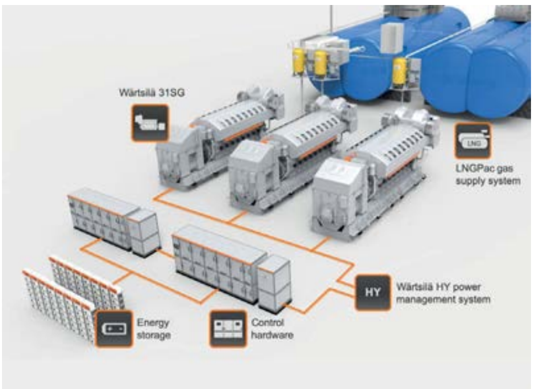
Wärtsilä launches pure-gas marine engine

Wärtsilä has announced a version of its Wärtsilä 31SG pure-gas engine for marine market applications at the Gastech 2019 conference in Houston. Based upon the successful Wärtsilä 31 four-stroke product platform, the new engine is targeted at regions where there is already gas infrastructure and will offer reduced operating costs and environmental footprint, according to the company.

The company says it delivered more than 1,800 engines and accumulated 37 million running hours for land-based applications of its SG lean-burn technology, with the Wärtsilä 31SG introduced to the market in 2017. Wärtsilä is attempting to reduce greenhouse gas emissions from its gas engines by 15% (from 2015 levels) by 2020 and believes the 31SG can help accomplish that, particularly with gas increasingly being adopted as part of hybrid propulsion installations.

"The gas-only focus and lean-burn technology allows for further optimisation of thermal efficiency, while lowering GHG emissions and facilitating adaptations for alternative heavier gas fuels, such as LPG," according to Rasmus Teir, product manager for Wärtsilä Marine. *NA*

The integration layout for hybrid installations featuring the Wärtsilä 31SG engine



Eliminating pilotage risk through considered design

Small improvements in ship design could have a big impact on the safe transfer of marine pilots

At a glance, pilot transfer arrangements appear to be a relatively simple aspect of ship design. Employing a pilot ladder and integrating any necessary transfer equipment won't affect a ship's stability, structural strength or mechanical performance. Proper planning and construction can, however, drastically impact the safety of marine pilots.

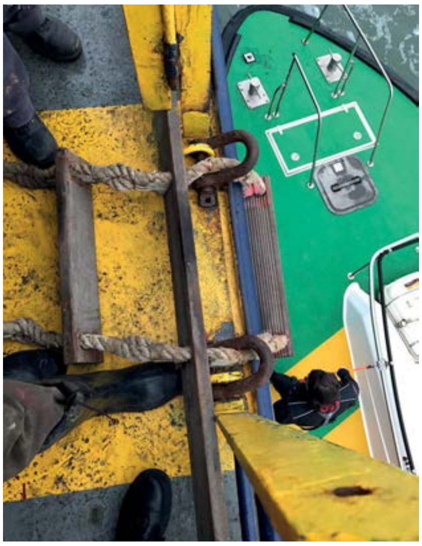
Yet, according to the International Maritime Pilots' Association (IMPA) 2018 safety survey "at least one in eight pilot transfer arrangements fail to comply" with SOLAS regulations. Some of these cases of non-compliance make pilot boarding unnecessarily dangerous, while others have resulted in fatal accidents.

SOLAS Chapter V Regulation 23, which came into force in 2012, outlines the requirements surrounding pilot boarding arrangements. Its starting sentence reads: "Ships engaged on voyages in the course of which pilots may be employed shall be provided with pilot transfer arrangements."

"To the piloting community that [sentence] means if we ever have to go onto a ship, they should be able to provide us with an adequate and safe pilot transfer arrangement," explains Kevin Vallance, a deep-sea pilot and author of The Pilot Ladder Manual, published by the Witherby Publishing Group. But this seemingly straightforward provision, he says, is too often forgotten about during the ship design phase.

"Vessels, like ferries, who think they're just going to be running from one port to another quite often don't do this. So, when they go off somewhere on a different route or off to dry dock, they can't provide adequate safe arrangement."

A prime example of this took place in 2016, when a passenger ferry built in Turkey – *Leiger* – was delivered to Latvia. As the vessel would only be serving domestic routes within Latvian waters, the shipowners claimed they did not need to comply with SOLAS regulations and made



A non-compliant ladder held on a spreader and shackles

no arrangements for pilotage related designs or equipment. This decision ignored the fact that the ship needed to call at seven different ports in order to top up with fresh water and fuel before arriving at its home port. "Each time the ship went to a port it had to take a

No constructional features should ever interfere with a pilot ladder

pilot which it could not provide safe access for," says Vallance, adding that such cases are not exceptional.

Safe access designs

Pilots can board a vessel either via a pilot ladder, a combination arrangement, embarkation platform or side door. Pilot ladders are continuously regarded by IMPA as the safest method for a pilot to embark or disembark a ship. However, nearly half of all non-compliant defects reported to IMPA are related to pilot ladders. Issues with bulwark or deck make up around 20%, combination arrangements 12.12% and safety equipment 18%.

For a ladder to be safely employed, 6m of horizontal unobstructed access is required within the mid-ship half section to allow the pilot launch to lie safely alongside. Anything positioned too far aft possess a risk to the pilot boat being drawn under the counter. Ladders must also rest firmly against the side of the ship without the interference of any constructional features, such as rubbing bands or belts, which could make the ladder difficult to climb.

IMO Resolution A. 1045(27) – Recommendation on Piot Transfer Arrangements – states that a pilot ladder attached to a winch reel should be secured through pad eyes located at least 915mm from the ship's side. It does not outline though where or how far the pad eyes should be from the ship's side when the ladder is not stowed and attached to a winch reel.

"If I was talking to a group of ship designers who asked: 'What's the single biggest thing we can do to make things safer?' I would say put all the pad eyes for securing a pilot ladder 915mm from the ship's side," says Vallance. Securing the ladder at least an arm's length away would ensure that pilots are not vulnerable to grabbing a hold of a section of unsecured rope once they reach the top of the ladder.

The point of access to a ship, regardless of whether that may be the top deck or a side door, must be free of trip hazards and have handrails or stanchions in place. This requirement positions cruise ships as one of the most frequent offenders when it comes to providing proper pilot transfer arrangements, says Vallance, as they nearly always lack any stanchions. "The side rope of their ladders will go up to the deck head through a shackle or pad eye and then they secure it down to the deck. It's clever but its non-compliant."

Shell doors or side doors, which Vallance describes as "brilliant, provided they're designed correctly", are another aspect of ship design that can have a significant impact on pilot boarding. He warns against trying to do pilots a favour by positioning side doors low on the freeboard, as you then risk a swell of water washing the pilot or crew out the door. Other design elements, such as correctly placing inserts into a ship's hull to secure an accommodation ladder used in a combination arrangement, can also minimise the danger during pilot transfers.

Early planning

Although Vallance makes it clear that there is no overall answer or one transfer arrangement to fit every situation, he does suggest that for safety standards to evolve, ship designers need to consider pilot boarding from the start. And the IMO agrees.

"Ship designers are encouraged to consider all aspects of pilot transfer arrangements at an early stage in design", reads the first line of IMO Resolution A. 1045(27). Why then does it consistently appear to be ignored? A key part of the issue, Vallance says, is that the rules on pilot transfer arrangements are spread between different sources – some of which are perceived simply as a recommendation rather than legal regulation.

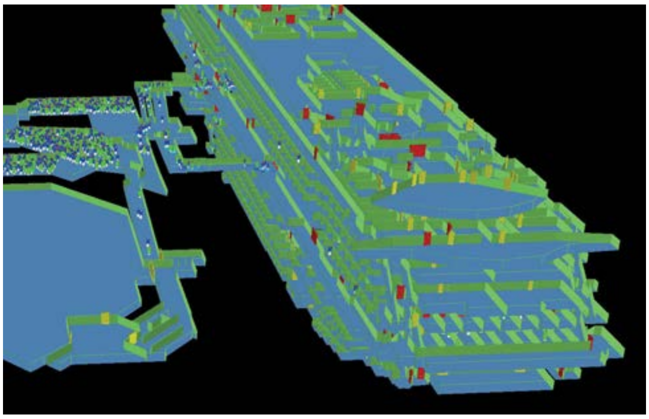
The pilot community is working to change this misconception and raise awareness through its #dangerousladders campaign on social media, which has sparked some necessary conversations within the maritime industry. But naval architects and ship designers haven't yet caught on to this cry for transformation. "The one group of people who are not communicating or interacting with us is the ship building community," says Vallance.

"All too often the ship's crew use the IMPA required boarding arrangements bridge poster as their only point of reference. This poster was intended to be used as a simple guide for the crew, but if the naval architects haven't complied with the requirements of SOLAS then the crew are placed at a great disadvantage.

"From our point of view, it's not asking too much to comply with the regulation." *NA*

Raising the standards of evacuation analysis

Yasmine Hifi, evacuation expert, Brookes Bell, explains the impact of IMO MSC.1/Circ.1533: 'Revised Guidelines on Evacuation Analysis for New and Existing Passenger Ships'



A still of a cruise evacuation and disembarkation simulation

IMO requirements for evacuation analysis have, until recently, only applied to ro-pax ships. However, from January 2020, all passenger ships (in addition to ro-ro passenger ships) carrying more than 36 people and with keel laid on or after the same date will have to prove adequate evacuation times through an evacuation analysis. Shipyards or designers will need to show that their design meets the IMO performance standard, which is the time taken to both muster and abandon ship. It is assumed that the preparation and launching of the lifesaving appliances (LSA) would overlap with the assembly process and is taken to be 30 minutes unless data from full scale trials, manufactures or simulations are available and could be used instead.

IMO's performance standard is defined as 60 minutes for ro-pax ships or ships with three main vertical zones or less, and 80 minutes for ships with more than three main vertical zones.

The main purpose of an evacuation analysis is to verify that a specific ship design will allow for people onboard to get to assembly stations in an orderly and timely manner by estimating the time required to abandon ship. Furthermore, an evacuation analysis can be integrated into the design cycle by highlighting areas of congestion or possible bottlenecks that can then be addressed.

IMO mandates that the analysis to estimate the travel duration to reach muster or assembly areas onboard the ship can be performed using either a simplified or an advanced method.

Simplified analysis

The simplified analysis provides a basic approach for calculating the required evacuation performance parameters required by the IMO and is most suitable at the early stages of ship design or for low complexity ship layouts. 'Simplified', however, does not necessarily mean less time consuming.

This methodology is based on defining the escape routes within the vessel as a hydraulic network, in which the public spaces are the tanks, the corridors and the stairs are the pipes and doors and other possible restrictions are defined as the valves. Several parameters such as "clear width" and "specific flows" are to be considered when defining the hydraulic network. Calculations for the simplified method could, hence, be performed within a spreadsheet.

Although this methodology is acceptable, it may not provide a time saving as expected, the calculation output may be difficult to validate, and modelling people movements as hydraulic flows can only offer a coarse view of what may happen during an evacuation. The benefits and the availability of tools on the market to perform the advanced evacuation simulation make it a much more attractive option.

Advanced analysis

The advanced analysis is based on performing computer simulations of the evacuation process: the ship geometry is modelled as built and passengers onboard are represented as individuals, referred to as "agents" within the simulation.

The model of the ship can be defined with a high level of detail and can easily be maintained and updated during the design cycle, from the very early design stage with a basic layout all the way to a very detailed final layout. People onboard, modelled as individuals, have unique characteristics (mainly represented by probability distributions) and can move towards specifics spaces whilst avoiding each other and other obstacles along the way.

Unlike a hydraulic model, a digital model of the ship offers a representation close to reality where not only escape routes are modelled but all spaces from passengers and crew cabins, to crew service and public areas are represented and are easily recognisable when viewing the ship model in 2D or 3D.

Performing an evacuation analysis using this methodology offers a host of additional benefits. Firstly, identifying areas of congestions and bottlenecks, which is an important part of the regulation, as well as location of cross and counterflow becomes much easier and more intuitive. Furthermore, as more simulations are performed, specific issues or areas of the layout can be investigated and modified to further optimise the design.

For any software to be accepted for use for as an evacuation analysis by the IMO, it needs, as a minimum, to demonstrate that it passes 12 specific benchmark cases defined in the regulation. These tests are designed to verify that differing components of the program are performing as intended, thus ensuring that the software is capable of modelling some key characteristics and behaviours of passenger dynamics.

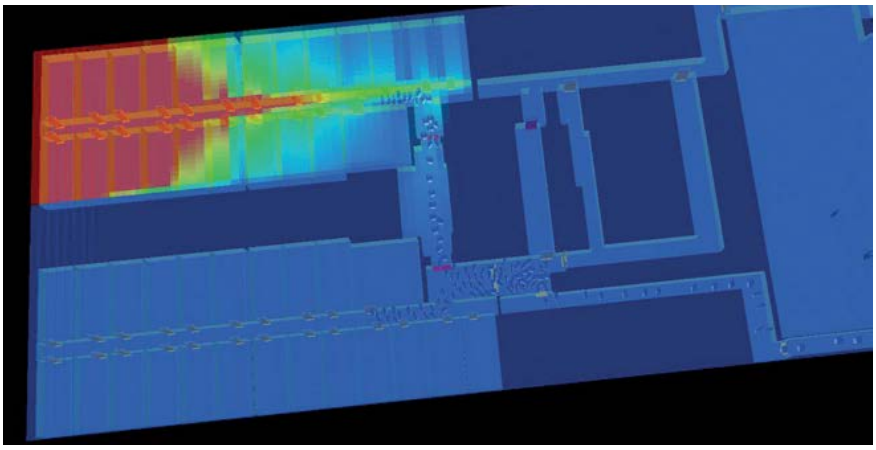
Grid-based or continuous space methodologies

There are two main approaches on the market today to modelling a ship using simulations: grid-base and continuous space modelling. Within the grid-based approach, the ship layout is simplified to a series of uniform grids for each deck. Each agent occupies one grid cell and makes their way to their destination by moving from cell to cell. Some variations also exist where an agent would occupy more than one cell and others where multiple agents can occupy a larger grid cell. Cells can be free, occupied or not allowed, representing walls, furniture or any other obstacles. An agent can only move to a free adjacent cell.

The main advantage of this approach is in the simplification of the overall simulation and hence the overall calculations. For example, simple transition and collision avoidance rules as valid or allowable movement is limited by the number of available free cells.

The major disadvantage, however, is the accumulation of errors introduced by the grid representation of the model: as the grid cell size is fixed (usually 0.4x0.4m^2 or 0.5x0.5m^2), the model of the ship geometry would need to be distorted to fit the grid. Additionally, the grid system also digitises the speed of motion as it can only vary (increase or decrease) in discrete steps governed by the size of the cell.

The continuous space approach instead produces a representation closer to reality as the geometry does not have to fit a predetermined grid. People can occupy any point in space as long as the space is not already used by another person or obstacle and can move freely in any direction with a speed of motion only affected by the simulation time step. The range and direction of motion are both restricted when people are in the close vicinity of a moving person to avoid collision. Collision avoidance calculation is more complex in this approach, but this does not present a challenge considering the computing capability available today.



A cruise evacuation with temperature overlay

How is an evacuation assessment performed?

To perform an evacuation analysis a number of specific scenarios have to be assessed each of which must be repeated multiple times in order to ensure statistical significance due, in part, to the fact that the variables that govern the process are defined using probability distributions. Ultimately, the 95th percentile of all the estimated travel times is used to calculate the total evacuation duration.

There is a total of four scenarios that must be simulated, each with a specific distribution of initial location of passengers and crew, reaction time and walking speed. They are split into night and day scenarios, each with a primary and a secondary case. The primary cases assume all escape routes will be available. The secondary cases are focused on the assessment of impaired escape routes and they are identified based on the results of the primary cases.

Two further additional scenarios are to be assessed depending on the type of vessel and design, these are:

- The open deck scenario which is applicable only if the vessel has an open deck area of more than 400m^2 for use by passengers. The open deck scenario would be assessed as a day case.
- The embarkation scenario, if the design locates the assembly stations away from the embarkation stations. If this scenario is simulated, then the estimated times to the embarkation stations should be used in the overall calculated evacuation duration instead of the default 30 minutes.

Meeting regulatory requirements and beyond

As a safety consultancy, Brookes Bell welcomes these changes in regulation as widening the applicability of evacuation analysis and increasing the focus given to evacuation considerations on the design and layout of passenger vessels can only improve the overall safety of more and more passenger vessels.

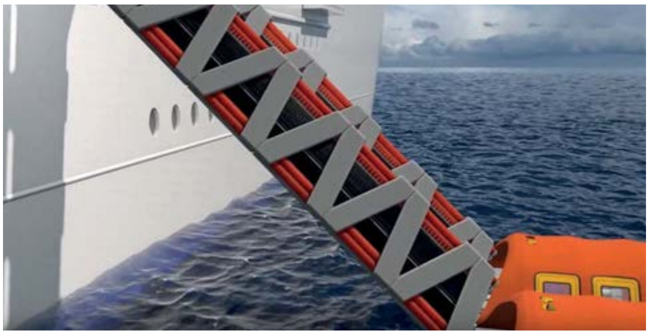
This article focuses on providing a high-level description of the impact of the regulations, the differing options available for designers in terms of tools available on the market, and the process of performing an evacuation analysis. Brookes Bell has been involved in passenger vessel design since the late 90s and provides the market with its advanced evacuation analysis tool EVI which has been used in a great variety of applications, from investigating ferries turnaround times while in port, escape planning from a dockyard during shipbuilding, to helping develop crew procedures during mustering and to improving passenger comfort through assessing service levels in public areas.

The benefits of pedestrian dynamics software are not limited to evacuation analysis only but can be used in assessing 'what if' scenarios and simulating situations that involve movements of people. These benefits go beyond meeting regulations to looking at different aspects of the customer experience. *NA*

Sliding to safety

A new approach to mass evacuation for cruise ships will re-write the rules for naval architects and ship designers. Richard McCormick, Survitec's technical sales director tells *The Naval Architect* about Survitec's plans for Seahaven as it prepares to meet IMO's A.520 regulation for novel LSAs

Seahaven launching



Passengers evacuate via high-pressure inflatable slides

Survitec's new solution for mass evacuation from cruise ships will not only improve safety during abandon ship situations but will release deck space by up to 85%, creating opportunities for naval architects and operators to think more creatively about how they approach ship design.

Seahaven is a self-propelled inflatable lifeboat accessed by high-pressure inflatable slides, which is stowed in a one deck-high rigid pod adjacent to the cruise ship. It is the only system of its kind that offers slide-based evacuation for large cruise vessels and is the largest capacity evacuation system to be developed. One Seahaven unit system consists of two inflatable lifeboats, accessed in tandem by a slide split into six paths – three to each lifeboat. Each unit can carry 1,060 persons to safety, with 530 persons in each boat.

Born out of a drive to find innovation-led safety solutions for the maritime industry, the premise for Seahaven was sparked during the 2005 EU-led and funded Safedor project. Survitec, which was involved in the Safedor discussions, revisited the concept in 2017 and for the past two years have developed the idea in consultation with operators, flag states and classification societies.

Mass evacuation has been on the International Maritime Organization's (IMO) agenda for decades. It currently recommends that passengers should be able to abandon (from muster to escape) a cruise ship within 60 minutes, but the height, length and beam of cruise ships have increased significantly over the decade, with today's largest cruise ships of 200,000gt carrying up to 12,000 passengers and crew. Evacuation from such vessels in the one-hour time frame using the IMO-stipulated lifeboat/marine evacuation system (MES) mix is an increasing challenge.

In 2009, four years after Safedor, IMO's Safe Return to Port requirement – which defines how long a ship should remain safe after an incident for it to be evacuated, and for how long it should remain afloat and be able to return to port under its own steam – came in to play.

These requirements were driven by the fact that the ship is the safest lifeboat, which even today few would argue with. But the fact remains that mass marine evacuation technology and design has not seen any significant breakthroughs since the first inflatable liferafts and MES were installed around 40 years ago. RFD Survitec was the original design authority for MES and first to develop MES in 1979.

Approvals and next steps

Cruise operators have been the driving force behind the call for new enhanced evacuation capability and maritime equipment manufacturers have stepped up to the mark. Seahaven, following five years of development, is one such solution and, in the spirit of the Safedor project, takes a completely different approach to all that has gone before it.

So new is the concept that IMO standards against which it can be benchmarked do not exist, and so Survitec is seeking IMO approval of the system through Resolution A.540, which sets the criteria for novel lifesaving arrangements brought to the industry.

This regulation lays out tough expectations for new concepts which go well beyond those of regular lifeboats, which in turn are put through their paces far more than MES (see box).

Consider current IMO regulations which recommend that passengers be evacuated within an hour; under SOLAS, passenger are required to be evacuated within 30 minutes. Survitec Seahaven testing estimates that the evacuation of 1,060 passengers takes under 20 minutes.

New solutions under A.520 are also

required to manoeuvre under their own steam in a seaway – again another difference to the existing requirements for inflatable rafts or MES which are not required to have an engine.

Seahaven, however, fulfils A.520 and goes beyond the requirements and is in line with Survitec's aerospace approach to developing and testing, which means it is designed and tested to function and perform, rather than merely comply with the requirements. Survitec is the only MES/liferaft manufacturer to hold ISO9001 and AS9001 the Aerospace standard.

During the development process, Survitec has successfully trialled its system, culminating in its recent April 2019 weather integration test in the North Sea with classification societies present. Whilst wave heights did not achieve the significant 3m+, as required by SOLAS for a full Heavy Weather Sea Trial (HWST), the system was deployed in wave heights up to 3.4m and both boats and system performed as expected, as well as allowing us to capture critical performance data.

We are now utilising the lessons learnt and waiting for the right weather conditions to put Seahaven through its HWST, which will see it perform in 3m significant wave height in association with a wind force of Beaufort Force 6 as required by MSC 81(70). We hope to have these completed by the end of this year.

Design features

A Seahaven unit consists of the inflatable slide and lifeboats, pod, and inside the pod the propulsion unit consisting of a motor driving a shielded propeller. The rigid pod not only protects the equipment when installed on the ship, it is also an important component of the boat and, when inflated, acts as the transom and supports the arch through which passengers will pass when entering the lifeboat.

Seahaven lifeboats inflate perpendicular to the ship, so that they can be steered away from the hazardous area as quickly as possible. However, Seahaven also features a skeg and keel for better manoeuvrability.

The high-pressure inflatable technology used in Seahaven is drawn from Survitec's defence division and has enabled us to create a slide 16m in length, as the higher the pressure, the higher the strength and therefore the longer the slide. Typically, MES slides have been limited to a maximum length of 14.5m, but this extra 1.5m makes it suitable for the freeboard of most cruise and passenger ships.

Bringing Seahaven to market

The long-term plan for Seahaven is to make it accessible to the entire maritime industry, at the moment our efforts are focussed on creating a qualifying design for the cruise and passenger ship industry, making it the ideal solution for mass evacuation.

We have already been working with forward-thinking ship operators who have pushed for such solutions and, safety aside, they can clearly see the commercial advantages that the smaller deck footprint will bring.

Few can see limitations to the system although it has been pointed out that it is not possible to test onboard Seahaven as you can a lifeboat. Some see this as a disadvantage as the monthly tests performed on lifeboats give operators and crew confidence that the equipment will perform in an emergency. As Seahaven is single-use solution, activated by a switch, we envisage that it will follow a similar onshore service schedule to that of MES.

Naval architects have been very open-minded about the possibilities and can see that ship design could change beyond recognition once traditional davit launched lifeboats situated over two-to-three decks are removed from the blueprints, and their expertise is invaluable. Ultimately the first class-approved installation can only come about with the input of all parties – equipment developer, operator including crew, naval architect, classification society and shipyard.

Looking forward, Seahaven could also be attractive to other vessel types, such as military vessels with large crew numbers, or smaller variants of it could be suited to utility vessels that want a streamlined deck and minimal footprint for safety equipment. Outside of cruise, Seahaven could eventually benefit the safety industry as an entirety. *NA*

Performance testing – lifeboats v. liferafts

Inflatable marine evacuation systems (MES) are today standard onboard cruise and passenger ships and ferries, and are rigorously tested to IMO regulation MSC 81.(70) standards. Despite the fact that MES are proven to be safer than lifeboats in an emergency situation, SOLAS still dictates that of 75% of the required 125% evacuation capacity on cruise ships must be lifeboats. 25% can be a mix of marine evacuation systems (MES) and lifeboats, and the final 25% can be liferafts. This means that a maximum of 50% of evacuation capacity can be given to MES/liferafts.

Richard McCormick, technical sales director at Survitec

Core technology and R&D planning for an autonomous ship

As the South Korean maritime industry prepares to embark on a six-year project to develop core technologies and infrastructure for autonomous ships in the country, Hwasup Jang and Jin Kim present an overview of the current state of smart ship technology and the methodology informing its approach

Autonomous ships are referred as the Maritime Autonomous Surface Ship (MASS) by the IMO. MASS could include ships with different levels of automation, from partially automated systems, that provide assistance to the crew to fully autonomous systems which are able to undertake all aspects of a ship's operation without the need for human intervention. However, the maritime industry uses a variety of terms such as 'smart ship', 'autonomous ship' and 'unmanned ship'. This article introduces the technology of autonomous ships, which in this context means partially autonomous vessels, and the R&D planning currently taking place in South Korea.

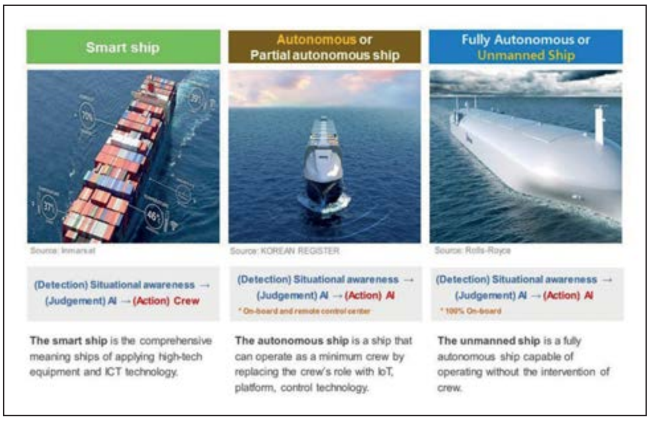


Fig. 1 Definition of autonomous ships

The background of autonomous ships

Autonomous ships have emerged in the maritime industry for safety at sea and efficiency of logistics (opex) based on the convergence with Fourth Industrial Revolution technologies (Artificial Intelligence (AI), IoT, digitalisation, etc.). Autonomous ships can replace human roles in both general and emergency situations by the system of AI to reduce human error, prevent accidents and improve the efficiency of operations. This can be considered with regard to two situations:

- General situations: Ordinary sailing, sailing in narrow channels/coastal, berthing and arrival/departure, cargo working, oil supply(bunkering), deck/machinery maintenance, and etc.
- Emergency situations: Fire/explosion, rough seas/low visibility navigation, sudden failure, emergency investigation in maritime terrorism, lifesaving, oil spill, hacking, and etc.

However, at the current technology level, it is impossible to replace both general and emergency situations with AI, and rather most research is being directed towards the systematisation of general situations. In other words, autonomous ships minimise the role of the crew (to cope with emergency) and replace most of the system.

Core technology of autonomous ships

The core technologies of autonomous ships can be classified into (1) situation awareness and detection technology, (2) platform-based judgment technology, (3) action and control technology, (4) infrastructure technology. Autonomous ships are capable of performing all detection, judgment, and action using AI. It is a system that combines technologies that allow the crew to solely monitor the results of action and only intervene – whether onboard or ashore – when absolutely necessary, as in an emergency.

Situational awareness and detection technology refers to a vision system that combines Radar, Lidar, and CCTV which can accurately recognise marine weather (wind, wave, etc.), objects (static and dynamic), and other ships (whether manned or autonomous) in any condition.

Platform-based judgment technology is based on data that is automatically collected and accurately predicted in real time via shoreside situational awareness and detection technology. In addition, it refers to a technology that automatically and safely navigates the complicated sea area and oceangoing routes.

Action and control technology refers to a technology that can control the ship through AI by adjusting the ship's position, speed, engine RPM, etc. and control the ship remotely on land in an emergency based on judgment technology.

Infrastructure technology refers to the laws, certifications, standards and port automation technology that these autonomous ships can operate commercially and reliably. In particular, preparations at ports are necessary for the docking of autonomous ships, integration of cargo loading and logistics information, and development of optimised ports considering the characteristics of autonomous ships.

Commercialisation and major issues of autonomous ships

In order for autonomous ships to sail internationally, not only technology development but also legal/standardisation

Classification	Contents
Technology	Reliability of intelligent system Convergence and interface between devices Cyber security/safety Big Data sharing and connectivity Interface with ports Coexistence and cooperation of autonomous ships and existing ships Cooperation with PSC and VTS
Legal/ standarisation	Autonomous ship insurance Autonomous ship management law Autonomous ship certification criteria Crew and operating personnel on autonomous ships Autonomous ship standardisation
Policy	Cooperation between shipbuilding and shipping Job change Social concensus Global cooperation system

Table 1

and policy must be resolved simultaneously (see Table 1).

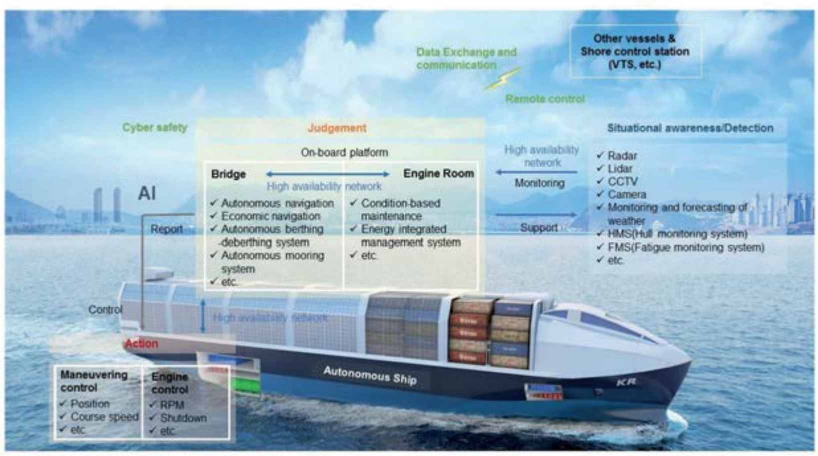
Therefore, it is necessary to develop a flexible and systematic response strategy and technology for future social changes caused by the emergence of autonomous ships through concrete design and analysis of major issues.

Technology status of autonomous ships in South Korea

In South Korea, the shipbuilding and shipping industries have committed to a six-year plan (2020-2025) upon completion of a feasibility study that will develop core technologies for autonomous ships and promoting technological development, including the verification and certification of those technologies. This project plans to development core technologies of autonomous ships to IMO Level 3 (unmanned remotely controlled vessels) and to establish methods and related infrastructure to verify the reliability of the developed technologies. Five principal objectives have been identified:

1. Development of advanced detection equipment for autonomous ships: It develops equipment that instantly detects the autonomous ships status and the surrounding navigational environments such as other ships and objects.
2. Development of autonomous intelligent navigation system: It develops the technology of autonomous operation in all navigating areas including a port.
3. Development of automated engine room: It develops the technology of failure prediction/diagnosis and fail recovery technology for automated engine room.
4. Development of autonomous ship sea-testing center and demonstration technology: It develops the technology of infrastructure and performance verification method to verify autonomous technology based on a real operation at sea.
5. Development of autonomous ship operation technology and standardisation: It develops the technology of safety, efficient operation technology and international standardisation technology of autonomous ships.

Fig. 2 Technical scheme of autonomous ships



Conclusion

A report published by Credence Research in April 2018 stated that the market size of autonomous ships is expected to grow to about US$155 billion by 2025. Furthermore, it is estimated that the market size will be about US$6.6 trillion by 2035, considering the current growth rate of all industries. Autonomous ships will be an inevitable trend. It is necessary to proactively respond by improving the maritime industry and securing technology, and to promote the commercialisation of autonomous ships through an international agreement on international standardisation.

South Korean shipbuilding and shipping industries are preparing the development of the core technologies for an autonomous ship with a support of National R&D projects starting from 2020. It would be expected that Korea will keep the global leading position in marine industries. *NA*

About the authors

Hwasup Jang is a senior researcher at the Korean Register (KR).

Jin Kim is principal researcher at the Korea Research Institute of Ships & Ocean Engineering (KRISO).

New tankers fly the flag for methanol as clean marine fuel

Does the delivery of *Mari Couva* and *Mari Kokaku* mark the next step in proving its viability as a clean alternative fuel?

Mari Kokaku was delivered by Hyundai Mipo Dockyard in September

In August, *The Naval Architect* was invited to attend a series of events marking the naming and delivery of two methanol-fuelled product/chemical tankers, *Mari Couva* and *Mari Kokaku*, at Hyundai Mipo Dockyard in Ulsan.

Built for Swedish shipowner Marinvest, the vessels are chartered to Waterfront Shipping, a wholly owned subsidiary of Methanex, the world's largest supplier of methanol. Waterfront currently operates 30 vessels and, with the addition of two further Hyundai Mipo-built tankers (owned by NYK and IINO/Mitsui respectively) later this year, 40% of these will be capable of running on methanol.

Seaborne trading in methanol has been taking place for more than 50 years, but its attraction as an actual marine fuel has only recently emerged with the search for greener alternatives. That it possesses just half the calorific value of traditional fuels is mitigated by the fact there is already a comparative abundance – around 122 million tonnes are produced annually – and mature bunkering infrastructure. A recent study by the trade association, The Methanol Institute, revealed that it is already available at 88 of the world's top 100 ports, with more expected to come online shortly.

Moreover, while it is still predominantly derived from hydrocarbons – be it coal or natural gas – there is growing interest in Power-to-X, or using renewable electricity to drive electrolysis to synthesise methanol with captured CO_2, as well as other renewable sources such as biomass.

"Methanol as a fuel concept began for us and Marinvest around 2012, with some discussions about the viability of retrofits," explains Waterfront's president Paul Hexter. "The decision was taken to investigate newbuilds and then in 2016 we took delivery of seven."

Those seven MR tankers were the first generation to be powered by MAN Energy Solutions' two-stroke ME-LGI engine, designed to switch flexibly between methanol and HFO, MDO or MGO. They typically engaged on long-haul journeys from Methanex's production facilities.

"To date we've run the engines on methanol for about 57,000 hours… Like any first-of-its-kind technology there's been some teething problems, but the MAN engines have proven to be technology that works," says Hexter. He adds that the vessels are 'sisters', irrespective of whether they happen to be running on methanol or conventional fuel.

The success of that first generation of vessels has helped advance wider acceptance of methanol as a marine fuel. As a low-sulphur alternative to MGO or LSFO that's competitively priced and widely available, it could also be in line for a boost from IMO's pending 0.5% sulphur cap. Although not referenced in IMO's IGF Code for gases low-flashpoint fuels, interim guidelines drawn up 2018 are expected to be formally approved by the Maritime Safety Committee next year. Instead, DNV GL conducted a risk assessment hazard identification study (HAZID) and made recommendations during the design process of *Mari Couva* and *Mari Kokaku*.

TECHNICAL PARTICULARS

Mari Couva and Mari Kokako

Length, oa:	183.07m
Length, bp:	175.15m
Breadth:	32.2m
Depth:	11.0m
Deadweight:	49,000dwt
Gross tonnage:	29,700gt
Main engine:	MAN B&W 6G50ME-C9.5-LGIM
Output (MCR):	7,180kW
Service speed:	14.5kts

MAN power

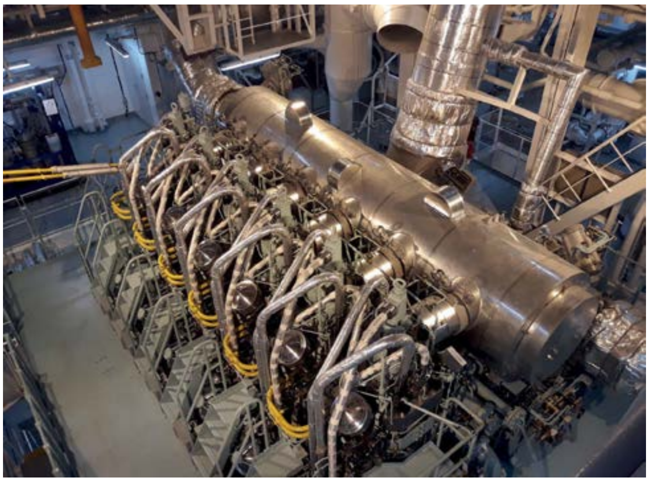
While the MAN Electronic (ME) engine was first launched in 2002 it has only become cost effective in recent years. The ME-LGI solution developed for the Marvinvest/ Waterfront vessels is effectively a standard diesel engine with an additional methanol injection system.

A small amount of pilot fuel oil is injected to control the ignition via what are known as the electronically controlled fuel booster injector valves (FBIVs), which are also essential for adding lubrication not present in the methanol. Each of the engine's six cylinders is equipped with two standard fuel valves and two FBIVs. Because the energy density of methanol is roughly half that of diesel it requires twice as much to be injected into the engine.

But with the second generation of vessels it has been possible to simplify this system.

"When you start developing an engine you have a wide safety margin as there are things that need to be tested over a long time period. But later you see the possibilities for optimisation," explains Kjeld Aabo, ME's sales director for new technologies.

"For the second generation we have done things like declination of the methanol inlet-outlet pipes, connection to the engine is now one block cylinder at cover No 1 and simplified connection to the FBIVs. Generally, we have done a lot to make it simpler and easier to maintain."



MAN's ME-LGI engine onboard the *Mari Couva*

However, perhaps the most notable addition to the latest iteration of the engines is the capability to add water into the fuel via a centrifugal pump. The purpose of this system, which can allow for up to 40% water in the mix, is to ensure the vessel fulfils NOx Tier III emission requirements with the use of exhaust gas recirculation or selective catalytic reduction (SCR) by reducing the combustion temperature. While this does mean the expenditure of additional energy to evaporate the water, Aabo says it is mitigated by the operational costs of an SCR (which require urea).

The water injection system was only developed subsequent to the signing of the shipbuilding contracts for *Mari Couva* and *Mari Kokaku*. This means it was not installed when they entered service as there was no time to conduct sea trials and they are currently operating with SCRs. Marinvest hopes, however, that given the comparative ease with which electronic controlled engines can be retrofitted, it will be a straightforward process to do so at a later date. *NA*

Simple containment solution diversifies market

LNT Marine's new innovative cargo containment system will enable more shipyards to build LNG carriers and fill a need for mid-size vessels

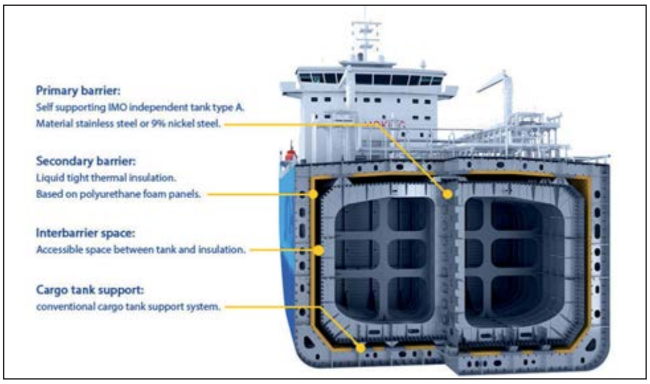
In 1964, the world's first purpose-built LNG carrier entered service, paving the way for commercial LNG carriers. The *Methane Princess*, a 27,000m^3 vessel, featured nine Conch independent cargo tanks insulated with a balsa wood insulation system attached to the inner hull. Although the vessel was a bold testament of the advancements in ship technology, other more popular cargo containment designs evolved to suit ever larger LNG carriers.

Today's global fleet is composed of two main containment systems: Moss and membrane. Moss-type tanks make up 33% of the global LNG fleet while membrane-type containment systems account for 67%, according to data published by IHS Markit. Of the LNG vessels on order, 91% are lined up for the installation of a membrane type system.

Traditionally, LNG has been transported around the world by large ocean-going LNG carriers, but heightened demand has prompted a rise in smaller terminals, more LNG ports and new trading patterns. This means that the distances between exporter and importer are shrinking rather than increasing in length, as was once expected.

With that, opportunities for new types of containment systems have emerged. One company on course to fill that market gap is Singapore-headquartered LNT Marine, with the introduction of its new patented system based on IMO independent type A tank – the LNT A-Box.

"There is a growing need for local and regional distribution of LNG, which requires a wide range of different ship sizes, as opposed to before where it used to only be large ships sailing from A to B", says Kjetil Sjølie Strand, CEO of LNT Marine. "When you have smaller users and small terminals you cannot accommodate the large ships everywhere in the world."



The LNT A-Box is based on IMO independent type A tank design, the simplest configuration according to the IGC Code

Historic solutions and new tech

By the end of 2017, there were 28 LNG vessels with a capacity of less than 25,000m^3, 464 vessels with over 90,000m^3 of hold volume, and only 19 vessels with a capacity between 25,000m^3-90,000m^3. Moss and membrane tanks dominate the large vessel segment whereas type C tanks are the preferred choice for small ships. None of these options, however, have proven to be very efficient nor adaptable for mid-sized LNG carriers.

LNT Marine, created following a merger between LNG New Technologies and MGI Thermo, began development on the LNT A-Box around 10 years ago. The prismatic containment system is based on similar design principles as the *Methane Princess*' Conch tanks but are arranged in a new patented-protected configuration. Classified under the IMO IGC Code as an independent type A tank, the self-supporting LNT A-Box is situated within an insulated cargo hold with a full liquid tight secondary barrier. It does not form a part of the ship's hull, but instead depends on bulkheads and internal structures for strength.

"This structure also acts as swash bulkheads," explains Strand. "That means you don't have any issues with sloshing in this type of tank and no loading limitations." Membrane tanks, on the other hand, are prone to sloshing because they lack any internal sub-divisions to break up the liquid movements.

The system, which has been granted approval from DNV GL, ABS, BV and CCS, also provides improved volume utilisation due to its flexible shape and geometry. Additionally, a cold inter-barrier space located between the tank and the full secondary barrier offers access for visual inspections and maintenance.

Another advantage of the self-supporting LNT A-BOX is that it does not have any impact on the insulation during normal operations. Therefore, the insulation doesn't need to be designed for dynamic loads from the cargo. "You can select relatively low-density foam for the insulation system, which is giving better thermal performance than if we had to use a foam with higher compressive strength, and this in the end translates into low boil-off rates. So, for the same thickness of insulation we can have lower boil-off rates than our key competitors," says Strand.

Type A tanks are based on classical ship structural design and construction methods, making them the simplest to design and build in comparison to other IMO IGC Code tanks. "It's relatively straightforward for most shipbuilders to build a type A tank," says Strand. "Thus, it differs from other containment systems in regards to construction friendlessness." Though he adds that shipyards, or tank builders, must have the competence to work with stainless steel, nickel steel or other low temperature steel grades.

One of LNT's primary aims with the LNT A-Box system is to enable a greater range of shipyards to enter the LNG sector. Thanks to the tank's easy fabrication and simple insulation system, it's expected that even shipyards without previous experience of gas carrier construction will be able to build LNG carriers at a reasonable cost with this containment system.

Saga Dawn is the first vessel to feature an LNT A-box

The next saga of LNG carriers

LNT Marine recently tested this claim with the construction of Saga LNG Shipping's newbuild, *Saga Dawn*. Ordered from China Merchants Heavy Industry, the 45,000m^3 capacity vessel is the first ship to feature the LNT A-Box and marks the first time the yard has constructed an LNG carrier.

"Of course, there's been a lot of learning for the shipyard and us on things that can be optimised. In principle though, its proven to be simple and without much need for special competence, equipment or tools," says Strand.

Saga Dawn is based upon the LNT45 ship design concept developed by LNT Marine in cooperation with Saga LNG Shipping – whose owner is a major shareholder of LNT Marine – and Swedish engineering group FKAB. The ABS-classed vessel successfully underwent gas trials in June and at the time of writing, was about to be delivered to Saga LNG Shipping.

LNT Marine is currently in talks to design and construct a second 80,000m^3 vessel with Saga LNG Shipping as well as possible floating units for other unnamed clients. Additionally, Strand notes that although the company's focus with the LNT A-Box initially has been mid-sized LNG carriers, the containment system could be scaled up or down for to suit other vessel size segments, as well as LNG fuel tank applications. *NA*

ClassNK powers into the future

ClassNK's Hayato Suga offers a progress report on the class rules that will enable safe use of LNG, hydrogen and other alternative energy sources so that global shipping can reduce its carbon footprint

As the conversation on alternative fuels continues to unfold, ClassNK is focusing on updating the rules that will ensure fast-emerging industry requirements meet safety imperatives, as well as the longer-term research needed to reconcile vessel operations with shipping's lower-carbon future.

Today, LNG represents a central strand in ClassNK rule development, both as a cargo and as ship fuel. The global LNG carrier fleet currently comprises some 600 ships and is expanding. In Japan, the major yards such as Mitsubishi, Japan Marine United (JMU) and Kawasaki are working on newbuilds, while their Korean and Chinese counterparts have an expanding orderbook. What this aggregate statistic doesn't reveal is a structural shift in the fleet.

LNG carriers have traditionally been placed on long-standing charters to support projects between a major energy supplier and set customers. Recently, however, new players are joining the market to satisfy emerging demand in small-scale LNG distribution to pockets of stranded demand and in bunkering LNG as a marine fuel. As these new entrants typically have less experience than established carrier operators, our activities in rule development and spreading the best practices are more important than ever.

Requirements for gas carriers

Last year we released our revised 'Guidelines for Liquefied Gas Carrier Structures', considering specifically the case of independent prismatic tanks. The amended text describes the technical requirements for direct strength analysis (DSA) and for fatigue assessments.

DSA specifies a method for calculating yield strength and buckling strength based on net scantling of primary structural members, drawing from in-depth research and experience from other vessel types. The document also presents assessment methods taking account of the complex interaction of loads between hull structures and cargo tanks which are independent of each other.

The guidelines specify not only the design loads dominant for each structure, strength analysis methods and corrosion deductions, but the design scenarios in which assessments are required by the IMO IGC Code. Therefore, it covers all structural requirements for gas carriers with independent prismatic tanks.

The updated guidance outlines strength assessment methods against fatigue cracks caused to vessels by prolonged and repeated loads. The original guidelines assumed some very conservative starting conditions, which resulted in what we now assess to be excessively cautious fatigue life predictions. Using data on the conditions these vessels encounter in actual operation, we were able to refine our starting assumptions, which led to a more precise calculation methodology for both hull structure and independent cargo tanks and their associated support structures. Of course, field data has to be treated with caution and supported by fundamental research as it is based on the conditions met during normal safe operation and not behaviour in more extreme circumstances.

Hayato Suga, ClassNK

Alternative fuels

Looking further ahead, it is essential to comply with IMO's agenda to reduce international shipping's dependency on fossil fuels as part of a wider environmental commitment to halve greenhouse gases (GHG) by 2050. As the shipping industry pivots to cleaner modes of operation, shipowners are showing greater than ever interest in LNG as a fuel. As a case in point, ClassNK granted an Approval in Principle (AIP) to the design of an LNG-fuelled 200,000dwt bulk carrier jointly developed by NYK Line and JMU in July 2018, to Kawasaki Heavy Industries (KHI) for their project on the concept design of an LNG-fuelled 207,000dwt bulk carrier in January 2019, and to Sanoyas Shipbuilding Corporation for their project on the concept design of an LNG-fuelled wood chip carrier in May 2019.

Despite the additional weight of their LNG fuel tanks and fuel supply systems, these ships have a larger cargo hold capacity and, by running on LNG, they are expected to satisfy Phase 3 of IMO's Energy Efficient Design Index (EEDI).

Other than LNG, alternative fuels such as LPG and methyl/ethyl alcohol are also considered to be a viable option for ships. These alternative fuels have lower flashpoints compared to traditional fuels; therefore, particular attention needs to be given to ensuring adequate safety precautions when using low-flashpoint fuels in order to decrease the potential risk of fire and explosions that may arise as a result of fuel leakage onboard the ship. International safety requirements for low-flashpoint fuels have been discussed at IMO and as a result, the 'International

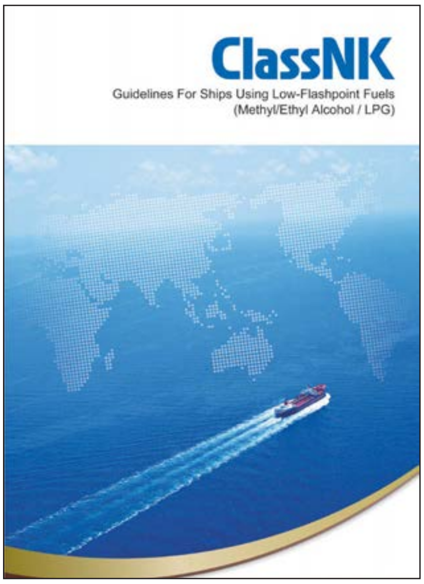
Code of Safety for Ships using Gases or other Low-flashpoint Fuels' (IGF Code) has been adopted and enforced. However, the current code does not address specific regulations for alternative fuels other than LNG.

To promote the design of alternative fuelled ships, we released the 'Guidelines for Ships Using Low-Flashpoint Fuels (Methyl/Ethyl Alcohol/LPG)' which outline safety requirements for other viable alternative fuels besides LNG, based on the latest technology and regulation trends. The guidelines divide targeted vessels into three categories: ships using methyl/ethyl alcohol as fuel; ships fuelled by LPG; and liquid gas carriers fuelled by LPG. They take into consideration the properties of each fuel type and ship regulations and indicate safety requirements for the arrangement and installation of the low-flashpoint fuel related systems for minimising risks to vessels, crew, and the environment.

Fuel methanation has also gathered global attention as a method of technology that may greatly contribute to the reduction of GHG emissions. ClassNK currently participates in a working group for the reduction of CO_2 emissions in the international value chain by use of methane synthesised through methanation technology which combines CO_2 and hydrogen produced from renewable energy sources. The technology is still relatively new, but if methanation proves to yield positive results in the long run, the supply of synthesised methane may greatly increase as it comes into widespread use.

Next generation alternative fuels

As a low carbon energy source, hydrogen is stirring up excitement as a promising alternative to conventional fuels, as the only waste product discharged at the time of power generation is water. Hydrogen can be burnt directly, like HFO, or used indirectly to power fuel-cells. In marine applications, the latter option is gaining traction as the technology is proven and efficiency is improving as manufacturers develop and refine the technology. Hydrogen-powered fuel-cells could reach a theoretical efficiency as high as 80%.



ClassNK's 'Guidelines for Ships Using Low-Flashpoint Fuels'

It should be remembered that hydrogen is a fuel carrier and its overall environment footprint depends on how cleanly it is produced and transported to where it is needed. The benefits diminish if fossil fuels power the production process. The dynamics become more interesting, however, if renewable energy sources are employed and a lot of practical research and activity is going on in this area.

Today hydrogen remains more expensive than conventional fuels, but the consensus is that costs will fall as production processes are refined and scaled up in response to growing demand, not just from shipping but more widely across industry. Therefore, in addition to economically viable and environmentally friendly methods of production, a secure supply chain will be required to transport hydrogen to where it is needed. In common with existing fuels, ships are likely to be the most efficient method for transporting large volumes over long distances.

Hydrogen transportation

The technology behind the storage and transfer of bulk liquefied hydrogen is not new, with land- and barge-based facilities supporting the space industry being in place since the 1950s. The same technology and standards can be applied to carriage by sea, albeit with modifications to suit shipborne operations.

Currently, the 'International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk' (IGC Code) outlines safety requirements for gas carriers like LNG. However, there are no specific requirements defined in the code applicable for liquid hydrogen carriers that take account of the hazards associated with its handling and transport.

Hydrogen must be kept at temperatures below -253°C in order to maintain its liquid state under atmospheric pressure, presenting an even tougher challenge than LNG. In response to growing interest in LH2 transportation, IMO developed 'Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk' – based on proposals from Japan and Australia and subsequent follow up by a specially convened correspondence group. These proposals were adopted at MSC 97.

Utilising its wealth of technical expertise and extensive experience in gas carrier R&D and ship classification, ClassNK has taken this work further by developing 'Guidelines for Liquid Hydrogen Carriers' based on these interim recommendations and other related international standards. These guidelines set out the safety requirements, which must be met in the design and construction of such ships to address the hazards arising from the handling of liquid hydrogen.

It should be noted there are some areas where the behaviour of the cargo cannot be determined with absolute certainty. Seaborne trials will be needed to resolve this to derive the data needed to refine the requirements and develop processes necessary to support large-scale commercial shipments.

In 2020-2021, the world's first project for producing and transporting clean hydrogen from Australia to Japan will begin, and ClassNK will join the project to evaluate the safety of Liquefied Hydrogen Carriers from the perspective of a classification society. *NA*

LNG carrier designs reflect continued market evolution

Innovation in the sector is not standing still, says Patrick Janssens, VP of Global Gas Solutions, ABS

For LNG carrier owners, vessel configuration continues to be defined by two choices – propulsion and containment system. But while the typical size of LNG vessels appears to have stabilised, there are prospects for further evolution in vessel sizes and for greater use of reliquefaction for cargo flexibility as trading patterns change and slow steaming increases.

Propulsion system design has evolved to a position of dominance for two-stroke engines of which there are two main types: MAN Energy Solutions' ME-GI high pressure gas injection system and Win-GD's X-DF lower pressure system.

These two designs have made up the vast majority of new orders in the last 12-18 months, with a slight preference for the X-DF system which is making up share against a higher installed base of ME-GI units.

Patrick Janssens, ABS

Despite the strong competition between the two providers, the differences between the systems mean they both have pros and cons.

MAN's ME-GI engine technology is agreed to offer a higher level of efficiency and operational flexibility and is less sensitive to fuel quality. It also has little or no methane slip, which is more common in the XD-F system. Considered a contribution to CO_2 emissions, methane slip is not currently subject to regulation, but there is increasing discussion suggesting it might be in the future.

The major advantage of the XD-F is the much lower pressure at which the gas is injected – around 20 bar – which contributes to reducing the capex on the fuel gas supply system and increases reliability. However, due to its different operating principles the efficiency of the X-DF is lower than the ME-GI with higher risk of 'knocking' and more sensitivity to fuel quality and methane number in particular.

The second area of focus for vessel designers is in the choice of Cargo Containment Systems (CCS) and, principally, the steady evolution in performance of the systems in terms of Boil Off Gas (BOG).

This is a process that has been taken place over the last five years or more, when Boil Off Rate (BOR) levels could be as much as 0.15% per day. The latest developments in membrane systems have brought this number down to 0.85% or in the case of the latest GTT Mk III Flex+, a BOR of 0.07%.

There has been a similar trend in Moss and SPB designs where the BOR has been brought down to the region of 0.8%, driven by the fact that propulsion systems have become much more efficient compared to the previous steam and Dual Fuel Diesel Electric engines. This means there is less need to manage the BOG by burning or reliquifying it.

The trend towards lower levels of BOR has prompted increased interest in installation of reliquefaction capacity, reflecting the desire to manage BOG for commercial reasons.

Reliquefaction capacity is common for both NO96 and Mark III containment designs. Certain shipyards also offer partial reliquefaction systems which can be employed in combination with a modern CCS using either a high-pressure gas compressor for ME-GI engines or a booster compressor for X-DF systems.

Using a system capable of reliquefying all or part of the natural boil-off enables the ships to slow steam when required without wasting excess BOG.

After a period in which yards and designers increasingly pushed the envelope in terms of LNG carrier capacity, the LNG market appears to have settled for now on ships sized between 174-180,000m^3.

While trends in vessel size are primarily driven by terminal capacity, there is also work being done by some shipyards to design a new 'post-Panamax' LNG carrier that can transit the new expanded Panama Canal locks with a capacity in excess of 200,000m^3.

Some Chinese receivers are reportedly interested in further increasing ship sizes, with a new design known as the 'Chinamax' of up to 260,000m^3. Whether this project comes to fruition remains to be seen – it appears that most charterers and owners are satisfied with the present standard sizes and there is no clear view whether many larger ships will be built or what their markets would be.

At the other end of the market, interest persists in small scale LNG where the majority of designers and owners prefer to build concepts around cylindrical Type-C tanks of around 7,500m^3, often for application in LNG bunkering. Projects include Singapore's first LNG bunker barge under construction to ABS class for FueLNG. *NA*

Dutch masters

Bolidt hopes to floor its rivals with the opening of a new innovation hub and a strong commitment to sustainability

It has been said that the history of The Netherlands is mainly a history of water, whether it's the land reclamation which began in the 14th century, it's emergence as a maritime superpower during the 1700's, its evolution into a shipping hub for European trade and the continuing importance of the Dutch maritime cluster as a hotbed for research and technology boasting one of the most modern fleets in the world.

Rotterdam in particular has established itself not merely as Europe's number one container port but also a 'brainport' for logistics, financial expertise and maritime innovation. Among those at the forefront of the Rotterdam cluster is synthetic flooring specialist Bolidt. Although active in other industries, such as public buildings, maritime is Bolidt's particular specialism, accounting for around 70% of its turnover. The main focus of those activities are in the cruise and superyacht sectors, although it is also involved in offshore and has even provided flooring for LNG carriers.

In July, *The Naval Architect* was invited to a preview of the Bolidt Innovation Centre, ahead of its official opening in October. Situated in the grounds of the Bolidt Campus, on the banks of the Noord river in Hendrik-Ido-Ambacht, it's a novel combination of research lab and interactive technology store, intended to showcase Bolidt's technical capabilities, brainstorm ideas and promote the company's drive towards sustainability. "We thought it was time to create a place where we can come together and have a conversation," explains CEO Reintz Willem Bol, who's father co-founded the company in 1964.

A fully integrated supply chain, Bolidt develops, manufactures and applies all its flooring solutions. It was among the pioneers in replacing traditional wood or metal decking with polymers, or more specifically thermosetting polyurethane-based resins, using its own custom-designed compounds. But like all parts of the marine equipment and materials industries it has found itself under increasing pressure to deliver lighter (synthetic floors typically weigh 40% less than traditional materials), greener and more durable solutions.

Bolidt's Innovation Centre is a space for discussing ideas and meeting clients, but also a working lab

That's particularly true of the cruise sector, where owners and operators are constantly seeking novel and innovative furnishings. Bolidt broke new ground in 2005, with the launch of Bolideck Future Teak, a synthetic teak solution which has become a firm favourite with the likes of Norwegian Cruise Line (NCL) and Royal Caribbean International.

Among the most eye-catching projects Bolidt has worked on in recent years is the 230m kart track that was installed on NCL's Meyer Werft-built 2017 cruise ship *Norwegian Joy*, for which it developed Bolidt Racetrack, a patented material based on road surfacing technology. Another has been the embedding of LED lighting into cruise ship decks, whether for decorative (as with the interactive artwork onboard TUI Cruises' *Mein Schiff 2*) or safety purposes, and developed in partnership with LED specialists. More recently, Bolidt has been developing flooring capable of detecting weight that uses a chemical current instead of wiring.

One of the striking aspects of the Innovation Centre comes at the core of the building, where the glass-walled R&D Hub is situated, allowing visitors to see Bolidt's chemists at work. There is also an advanced climate chamber and accelerated weathering laboratory. "We are working on a number of Polar and expedition cruise projects at the moment and these facilities will be put to good use developing materials that meet these needs," explains Jacco van Overbeek, division director for Bolidt Maritime.

Over the last few years Bolidt has strived to put sustainability at the heart of its business. Plant oil-based resins have replaced traditional oil-based versions, water-based sealants instead of solvents, prefab production, lightweight materials and the adoption of Lean principles are all now embedded in its operations. "But that doesn't necessarily mean we're the best boy in the classroom," admits purchasing manager Coen Geerdink.

The company's vision is for 100% sustainability, with plans for initiatives such as purchasing of reusable or biodegradable packaging, renewable energy, energy-efficiency and supply chain management. Already it is using 50,000kg per year of waste-derived grinded polyurethane (a substance that uncannily resembles chocolate powder) in its products.

Further ahead, there is an abundance of functional innovations in the planning. "For cruise we want to develop floors that are ocean plastic-based, generating energy, CO_2 absorbant, flow resistant, antibacterial, self-cleaning. We want to involve clients, suppliers, governmental and non-governmental organisations… anyone who can help us," says Geerdink. *NA*

Quality made to fit

Rommert-Jan Schoustra, naval architect with Blom Maritime, gives an insight into the application of 3D scanning and its potential to revolutionise ship design, production and maintenance

3D scanning is already common practice in the repair and conversion industry. The recent surge in scrubber and ballast water treatment modifications has also significantly increased the companies offering 3D scanning services.

In the repair industry 3D scanning makes it possible for engineers to make a new design on top of an accurate existing design. This significantly improves accuracy of the design, makes it possible to use more prefabricated parts and significantly reduces manufacturing time and project cost. This article shows some of the benefits 3D scanning can bring to designing a new vessel and how it can help the engineers.

When starting work on a conversion we always begin from a 3D scanned vessel. This makes it possible to adjust everything to the accurate geometry of the ship. A whole new design is laid as a puzzle over the existing ship, just as a GA engineer fits all necessary components into a new GA. Many years of experience have made it possible to work effectively in point cloud and to custom fit every solution to the ship.

Figure 1: Scanner and surveyor engineer

What is a 3D scan and point cloud?

A short explanation about laser scanning might be useful. The scanner (Figure 1) works like a 3D camera, using a laser to make distance measurements of everything in its field of vision. To collect data of a large area, multiple scans need to made and connected. The scanner produces millions of points that are combined in a point cloud, which is a cloud of each measured location. This point cloud can be converted automatically or by hand to CAD faces or solids. This makes it possible to gather the data as .stp, .dwg or any other commonly used format.

There are numerous open source or off-the-shelf software packages to show the point cloud. Our own in-house tool NUBES makes it possible to show a point cloud and a design on any computer with an active internet connection. This gives clients the possibility to check the custom design in the scanned virtual ship from their own office. It is a vital tool to communicate the design and show the clients exactly what will be installed. This will reduce risk, installation time and make sure there are no unexpected surprises.

Most engineering packages work on supporting point cloud data, which means that engineering can be done directly in the point cloud as well.

Feedback and making a virtual vessel

Even though the benefits of laser scanning is well proven for the repair and conversion industry, it's still relatively unknown in the newbuild and design industry. In the past the foreman and the engineer would actively work together and have regular face to face meetings. Nowadays the shipping industry has changed to a truly global industry, where often the design of the vessel no longer take place next to the shipyard. This means that designers are forced to use many video calls, emails, pictures and drawings to make sure their ideas are accurately produced.

3D scanning could be a very useful addition to the tools that are commonly used now. How many times have engineers been forced to try to see all the details from photos, which never show exactly what is needed? A photo or video will never be the same as actually being there.

But the next best thing is a point cloud, where the designer can walk through the virtual ship, measure required distances and check details. This point cloud can be referred to at any time and at any place to make modifications, troubleshoot or redesign. 3D scanning could be an

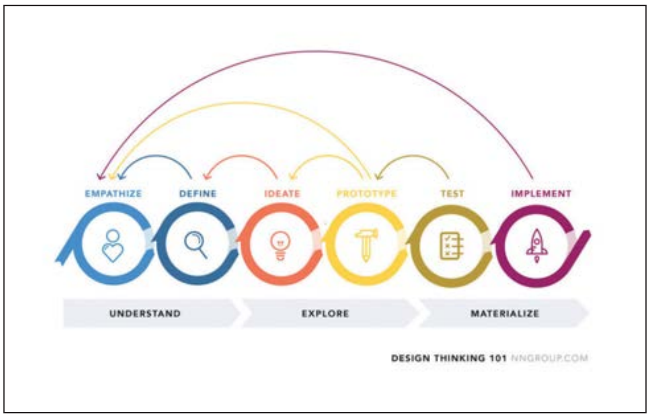


Figure 2: Design process (Source: Nielsen Norman Group)

excellent tool to make sure the feedback loop from implementation to empathise is made more clearly. The design loop itself (Figure 2) is assumed to be common and does not require further explanation.

It is not only highly rewarding for the engineer to see the design build, but it can also be very useful. Production mistakes can be picked up by the engineer but also smart production or design difficulties will become evident. This can be used as two-way feedback, allowing the engineer and producers to improve their skills. The scanned data can also be used for training new personnel where they can see how the drawings are used to build the ship.

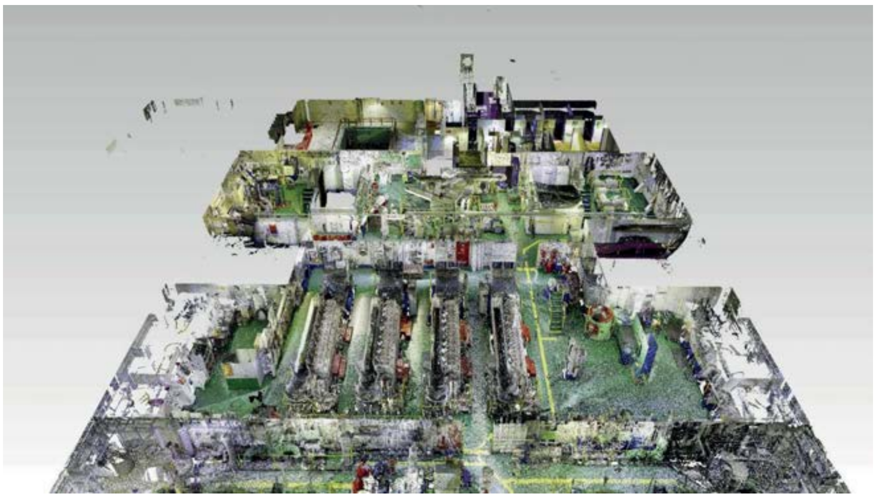
Digital twin of the vessel

As-built drawings are one of the most important operation and maintenance drawing packages that should be created after the vessel's construction in order to show all the differences between initial design and the final product. These can be made for structures, piping, electrical installations systems and any other systems onboard. Good as-built drawings can be very useful for the ship's crew during the vessel's operational life, whether to make alterations or just check what is onboard the vessel and how it is connected.

The biggest problem of as-built drawings is that it takes quite some time to produce them. Furthermore, because they should be produced after finishing the vessel, the engineering team is usually already busy with new projects. In real life, the as-built drawings are commonly seen as bureaucratic work after the ship has sailed.

With the new scanner hardware being able to perform a single scan in only 30 seconds, 3D scanning the vessel could be a viable alternative to producing as-built drawings. A 3D model can easily replace the current as-built drawings and could be given to the customer as part of the service. As an example, Figure 3 shows a scanned engine room and pump room.

Figure 3: Scanned engine and pump room



As-built documentation is the key to executing proper and time efficient operations and maintenance. Based on point cloud and 3D design, we are able to quickly access specific information related to each existing system or part of the vessel. Digital searching options of the point clouds make it possible to be in the area of interest within seconds. Changing the philosophy from manual searching in folders, drawing by drawing, to a digital option which provides us with a 3D overview.

All these technologies already exist and are implemented on a daily basis in existing plants thanks to, for example, AVEVA software. The technology and knowhow is available, the crucial aspect is implementing it and changing the way of doing things.

FEM and CFD calculations with scanned data as input

As any designer crunching numbers is aware the calculation is only as good as the input. Certain details can be drawn easily but never produced. Currently a good scan will have an accuracy of 1mm, meaning it can be used for CFD or FEM calculations with ease. Both FEM and CFD calculations have been done using this data and usually the meshing errors are bigger than the scan errors.

It is always important to make the input of these calculations as well defined as possible to ensure an accurate result. Most FEM and CFD software packages have good geometry packages, making it possible to insert a scanned geometry directly in the solver. Depending on the required accuracy it is even possible to let the software automatically produce surfaces and volumes directly from the scanned data.

Scanned data can be used as an excellent input to calculate the effect of production details. Sometimes, space requirements or production errors occur. To see if the structure is still strong enough to last the entire product lifetime a simulation can be done and if needed efficiently solved. Flows through piping, ventilation or along the hull can also be modelled around the real structure, including small deformations and details that might produce cavitation.

The second feedback loop from prototype to empathise can also be easily performed using a scanned model. It is even possible to create an object in the workshop without drawings and then use the scan to make all necessary calculations. This reverse engineering could make the out-of-the-box prototyping a lot quicker. It also helps in the second feedback loop in Figure 2, prototype to empathise.

Figure 4: Scanned hull in dry dock

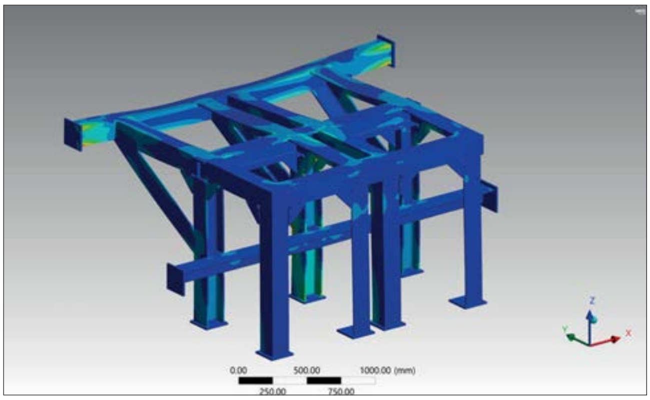


Figure 5: FEM calculation results of existing supports

Conclusion

3D scanning, software and computing power is becoming cheaper and faster every year, making new applications which were too expensive and time consuming in the past possible. This article has shown some of the possibilities of 3D laser scanning but certainly not all. The possibilities are limited only by our imagination and determination.

About us

BLOM Maritime is a world leading supplier of 3D digital data capturing. We specialise in capturing and optimising 'as-is' data for improved engineering and project execution. We provide full-cycle service while ensuring that cost effective solutions are continuously implemented before, during, and after the projects.

We are part of the TECO Maritime Group. Our subsidiary offices, along with business partners are strategically positioned worldwide to ensure a fast response and reliable service throughout.

The entire network of subsidiaries and strategic business partners employs more than 170 employees worldwide. To date we have successfully completed in excess of 3,000 projects, combined from within the various industries we serve. *NA*

Enhancing the capabilities of Digital Twins

NAPA's joint research project into Digital Twins, in collaboration with DSME, KMOU and AVL, will create pathways for autonomous ships, writes Deok-Hoon Jang, NAPA Shipping Solutions

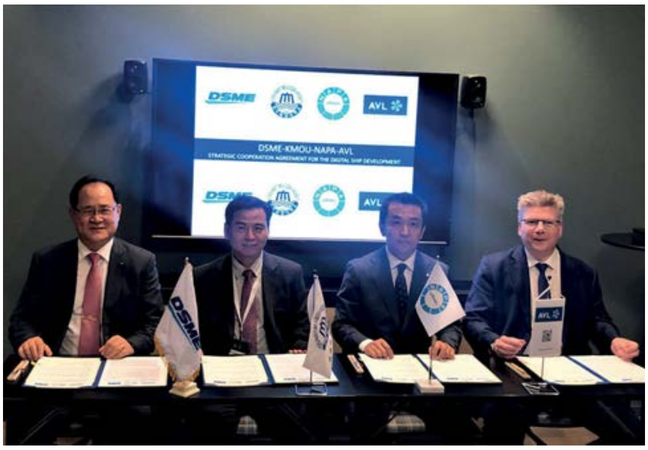
Earlier this year, at Nor-Shipping, NAPA announced a project with Daewoo Shipbuilding & Marine Engineering (DSME), engine research institute AVL and Korea Maritime & Ocean University (KMOU) to explore digital ships and related strategic solutions. The partnership will combine a variety of disciplines; bringing together naval architecture, shipbuilding, engines, big data, and software development to push the boundaries of digital twins.

Each partner brings a different angle to the collaboration, co-ordinated by DSME. NAPA, experts in maritime software and Big Data, together with AVL, the world's largest independent company for the development, simulation and testing technology of powertrains and propulsions systems, will develop Digital Twin ship models with digitalised components and a real-time simulation platform to integrate between engine models and ship models, including the simulation tools and methodologies that the partnership projects will require.

KMOU, as a world-leading research institute in the field of maritime studies, transport science and engineering, will contribute by providing the existing infrastructure as a basis for further development and optimisation.

The development of Digital Twin ships and engines is one of the most exciting outcomes of the recent surge in maritime digitalisation and its combination with the Internet of Things. By creating a virtual, real-time copy of ship, engine and related systems, we can better monitor, analyse, and predict performance, leading to safer and more efficient operations.

This collaboration aims to create the most comprehensive Digital Twins possible: from the acquisition and processing of quality machinery data, ship performance and meteorological data to the training, simulation and human machine interface that will be necessary to turn insights from ship's operational data into practical efficiencies.



From left to right: Odin Kwon, DSME, Deog Hee Doh, Korea Maritime and Ocean University, Naoki Mizutani, NAPA and Marko Dekena, AVL LIST signing the co-operation agreement at Nor-Shipping 2019 exhibition in Oslo

Improved simulations

The effort required to set up and integrate advanced real-time models on a component and system level is considerable; but it's worth it. Firstly, it allows us to improve what is generally seen as the classical use case for a digital twin is system simulation – testing compatibility and interoperability between subsystems. As owners realise the benefits of digitalisation, and the need to future-proof vessels at the design stage by better integrating sensors and automation systems, designers and yards are beginning to increase their focus on the design of electronics and digital solutions. Better Digital Twins allow us to better simulate the interaction of these systems, doing for the digital design of ships what CFD does for hullforms.

However, this collaboration allows us to go far beyond this. AVL's expertise and detailed database on engine performance means the group will be able to add even more detail to these models to simulate engine behaviour. Adding real-time capable, physics-based engine models with crank-angle resolution, for instance, allows the consideration of different engine phenomena into our performance models. The challenges will be how to overcome the trade-off between real-time capability versus model fidelity, as well as the interoperability and the aligned cooperation of partners when it comes to model properties and quality.

Particularly when inputting detailed information on engine components, Digital Twins create possibilities for predictive operational planning, proactive maintenance, and optimisation of spare parts logistics. Virtual sensors can also be used to create bridge assistance systems and simulators for training purpose, further enhancing operations.

What's more, Digital Twins can be used at the vessel design stage. By creating a detailed model of both engine and hullform, we can simulate and iterate better designs, optimised for specific performance goals. These ship performance models are hydrodynamic models that consider the coupling effects of wind, waves, current, and shallow water, combined with a full model of the propulsion and engine system.

Performance predictions

NAPA can address the force balance of all these factors by considering data on operational speed, and in actual wind and wave conditions, based on thousands of individual voyages collected in its Fleet Intelligence solution. These models are already used to simulate voyages and likely performance, using the results both to improve routing, performance and maintenance schedules, but also to optimise design and hull form.

Collecting data points hourly from each ocean-going ship – including position, speed, wind conditions, sea currents, and wave and swell height, direction and period – allows for continuous improvement of NAPA's datasets and creates ever-more accurate performance predictions. With better models, and more detailed engine information, these iterative design solutions can be put to better use.

One of the most potentially exciting outcomes from this partnership will be the possibility of Digital Twins being used in stability management of autonomous vessels. Stability management remains a critical part of the design process whether it is for a manned or autonomous vessel – and Digital Twins will be essential to the success of this.

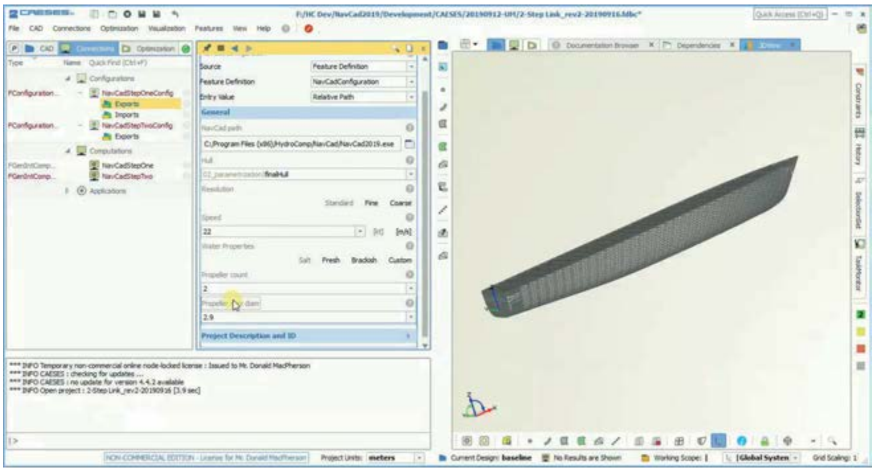
Stability computers, which typically process data for up to 200 sensors sources, are integral to stability management – both by providing better information to crewed ships and, further down the line, to autonomous vessels. They create situational data and predictions to be processed, and can also include monitoring for weather, cargo displacement, and other technical areas. This can then be analysed from ashore using cloud-based software; which then in turn, with increases awareness of forecasted weather along the sea passage, optimises the ships performance, and increases cargo and ship safety. The more accurate the virtual version of the vessel, the better the ability of the stability computer to maintain safe operations.

In conclusion, Digital Twins bring together a range of different fields of expertise, requiring hardware, software and operations to work together. This is why collaboration is essential if this technology is to mature. This partnership represents shipping's best minds in shipbuilding, engines, ship operations, and software – and NAPA is excited to work together to develop digital twin technology and a platform that will make future generations of ships safer and smarter. *NA*

Notes from the CAESES users meeting 2019

More than a hundred international engineers, naval architects, CFD specialists, and design experts met in Berlin in September for a conference focused on applications of CAESES, the popular design optimising tool. HydroComp's Don MacPherson reports on some of the talking points

For those not familiar with CAESES, this is a high-level design tool from Friendship Systems AG for the development, management, and optimisation of products and vehicles. It provides two principal capabilities – CAD design (particularly for shape development) and optimisation using a variety of design strategies by connections to simulation solvers (such as CFD or our own NavCad software). HydroComp was pleased to be a sponsor for the event, along with colleagues from companies developing tools that connect with CAESES for CFD simulation, gridding of geometries, and High-Performance Computing.



CAESES setup to launch NavCad GUI for initial prediction configuration

CAESES for design optimisation

While our interest is in marine vehicle and propulsor design, CAESES is not limited to these disciplines. Its creative approach to shape development by parametric shape creation or defined control of morphed geometries allows a designer to build any parent shape for any purpose, connect it to performance solvers, and run an optimisation for a defined objective. For a vision of what future design might look like, Dr Yuanjiang Pei (of US-based Aramco Services Company) gave an interesting talk on how internal combustion engine design can be accelerated with the use of High-Performance Computing and Artificial Intelligence. He was careful to point out that these tools support and enhance – and do not replace – and engineer's experience, knowledge and skills.

Among the various design studies discussed at the CAESES Users Meeting 2019 (UM2019) were presentations about wind turbine multi-element blades, turbochargers, water turbines, engine compression and ignition, and pump impellers and volutes. Of course, marine vehicle design held a prominent place at the UM2019, with extensive presentations about America's Cup catamarans, early stage design of cargo ships, asymmetric sterns for pre-swirl benefits, and a multiple presentation track of reports from the EU HOLISHIP (Holistic Ship Design) initiative.

While many of the ship design presentations used minimum resistance as an objective function, we want to caution that this is only valid if the ship speed and displacement is held constant throughout the optimisation study. For a multi-speed weighted objective, resistance should never be used as this does not capture the 'cost' part of the cost-benefit optimisation. If we reflect on the real 'cost' of ship ownership or operation in the context of its performance, it is power that is most important. Resistance is just a means to get to power. (Still not sure? Consider a planing hull resistance curve. There can be a broad speed range where resistance is more-or-less constant – but power is definitely not.) Using drag as an objective function discounts the significance of the "cost" of resistance at higher speeds. So, we always recommend using effective power (which is simply drag times speed) as the objective for all resistance-only hull form optimisations. Of course, for a more rational and thorough investigation of best performance, the connection objective of the optimisation would be the best combination of hull shape and propeller design over a full mission profile for minimum energy, fuel consumption, or emissions.

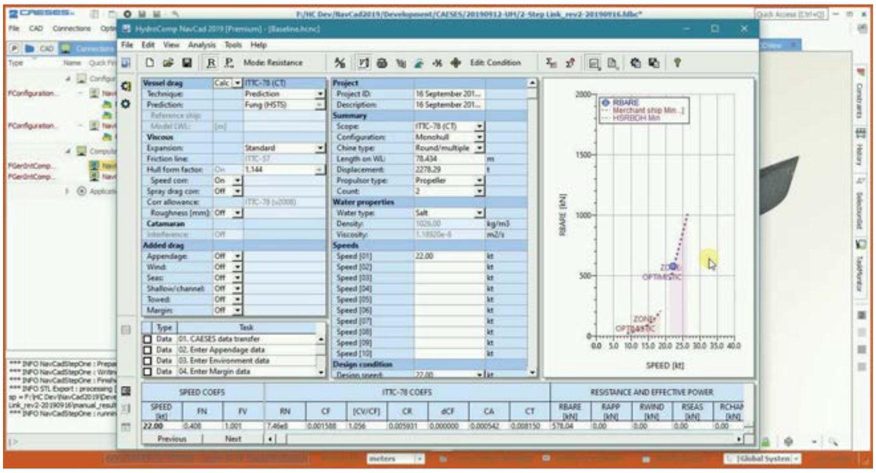
New CAESES-NavCad connection

The event also provided an opportunity to introduce the latest implementation of a CAESES-NavCad connection. Our project demonstrator was a high-speed round-bilge transom-stern patrol craft, with a very simplified objective of minimum bare-hull drag.

The benefits of the new CAESES-NavCad connection for ship design are profound:

- The workflow is a simple two-step process of Configuration and Evaluation.
- Configuration is within the NavCad GUI, with setup guidance provided by an initial Task List, use of the Method Expert ranking feature, review of prediction Confidence Plots, and discovery of "super parameters" exposed with the minimum drag utility and ADVM 'Longitudinal Energy Plot'.

- For a full Vessel-Propulsor-Drive system optimisation, a design study can be prepared with the CAESES-NavCad connection to find the best mission profile energy usage, including definition of an optimised propeller within each variant evaluation and prediction of fuel use and emissions.
- For an advanced study, total required mission fuel volume and mass can be calculated and returned to CAESES for update of fuel tank design and vessel deadweight.



NavCad completion of the baseline parent design, ready for optimising

This now provides an opportunity for new users of either tool to immediately exploit the power and design creativity found within the connection. The initial configuration for the calculation settings takes only a few minutes (as compared with one or two days with higher-order codes). Evaluation of design variants also is very rapid with dozens of variants developed, transferred, and evaluated in just a few minutes.

Additional information about CAESES and the User's Meeting 2019 can be found at www.caeses.com. Details about the new CAESES-NavCad connection can be obtained by contacting HydroComp at info@hydrocompinc.com, www.hydrocompinc.com. *NA*

Experience with Virtual Reality aided design and engineering

Naval architects Knud E. Hansen give an insight into how it has incorporated its proprietary VR system ShipSpace into the initial design process

Engineers and designers at naval architects Knud E. Hansen have been exploring and developing Virtual Reality (VR) with the use of ShipSpace since 2016. "Feedback from our customers has been tremendously positive about the use of VR for ship design", says Ken Goh, a senior mechanical engineer in the company and an advocate for the technology from the outset. "Drawing reviews are still necessary, but we get much more thorough and richer feedback when it comes to reviewing working spaces and accessibility issues. People are astounded by how realistic VR is, how they can move and see in a very natural way. They are able to use the VR tools in just a few minutes. Even reluctant users are comfortable and productive in less than half an hour."

Goh notes that many early adopters have been put off using VR because of poor implementation and performance issues. "Earlier VR theatres and caves cannot really be considered as true VR since they have many display inaccuracies due to the projection limitations, people often get motion nausea after 10-15 minutes as they are flown around by another person. With ShipSpace and the Head Mounted Display (HMD), the view is 100% accurate. You are fully in control of what you see and how you move around the space. You also always feel secure because you're always standing on something."

Regardless of the benefits of HMDs over earlier VR systems, poor user interfaces and inadequate graphics performance with stuttering and laggy image display, will still lead to a poor VR experience. Goh says: "Without the correct computer hardware and software the VR experience can be unconvincing, uncomfortable and can quickly cause disorientation, nausea and headaches for the user. These are problems that ShipSpace has been specifically designed to overcome. We regularly have had people using ShipSpace for hours without any motion nausea issues."

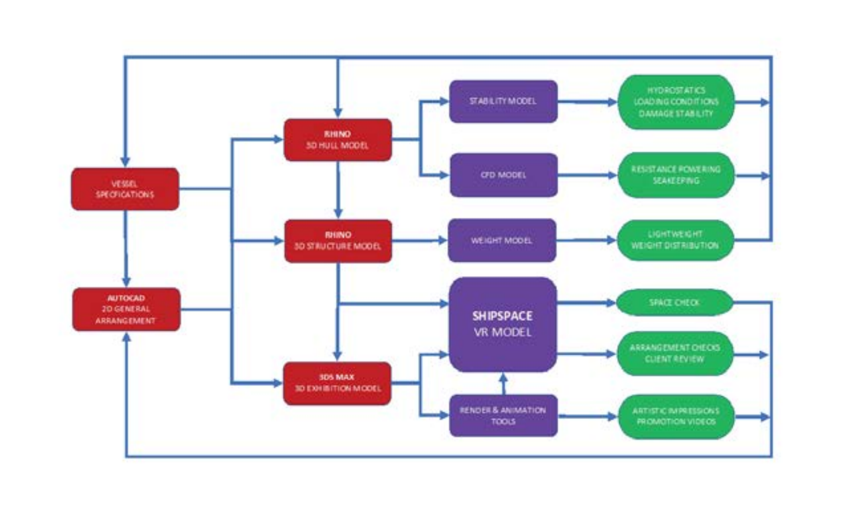
	Space required	Cost	360 degrees	Close objects	View accuracy	Wearable	Motion nausea
Theatre	Medium	Low	No	Yes	Low	Glasses	High
Caves & domes	High	High	Yes	No	Medium	Glasses	Medium
Head Mounted Display	Low	Medium	Yes	Yes	High	HMD	Low

Figure 1: Benefits of HMDs over legacy VR types

Since the majority of design work undertaken by the company is in the initial design phases of a vessel project, the challenge has been to find more efficient methods and processes to enable the 3D digital models required for VR to be used earlier in the design process. In commercial ship design, typically there are only a few thousand hours to develop the initial concept design including studies, arrangements, calculations and specifications. In contrast, during the detail design phase, many hundreds of thousands of hours can be spent on the 3D models required for the shipyards' production processes. It is worth noting that 75-90% of the ship's acquisition cost is committed in the initial design phase despite only 1-2% of the ship budget being spent on the concept design.

Every design still needs to start with a 2D general arrangement drawing, specifications and initial calculations. The hull is then modelled in 3D so that the vessel stability and hydrostatics can be assessed. The hull lines can then be adjusted for buoyancy and weight moments and

Figure 2: Initial design workflow and modelling



then used for CFD modelling to refine resistance and powering estimates. From the stability model, the surface areas, centre of mass, and weight distribution for all the compartment bulkheads can be collated to refine the structural weight estimate. The superstructure is also simply modelled in 3D so that the entire vessel weight can be more accurately calculated. This is important since the structure accounts for 60-80% weight of an unloaded vessel depending on ship type.

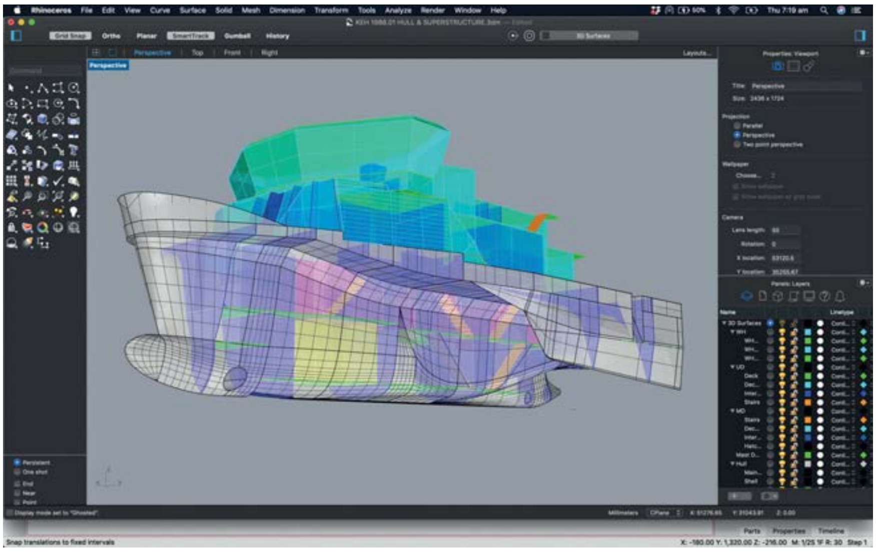


Figure 3: Simple hull and structural 3D model

These simple 3D models can then be checked with ShipSpace VR tools to ensure all the vessel's compartments, tanks and voids, especially those with highly irregular shapes, can be suitably manufactured and be accessible once built. Making changes to watertight compartments later in the design process can have large repercussions on the arrangement of the vessel. These early checks can significantly de-risk the vessel's final design and make for a better designed vessel in which use of space has been highly optimised without effecting manufacturability or serviceability of the new vessel.

The simple 3D model can then be quickly brought to life by embellishing with external details, textures and colours. At the initial design stage, this model needs to be aesthetically accurate even though technical accuracy of details is low. For example, even though the lifeboat has been specified, the actual maker and model have not yet been chosen, so such details are more representative than necessarily accurate. External renders of this exhibition model give the customer an accurate visual impression of the vessel. Furthermore, the model can be explored at full scale with the ShipSpace VR system to give the customer the most realistic experience of the new vessel and allows for detailed feedback about the arrangement that is simply not possible from just looking at drawings or pictures.

Adding interior details to the model also enables the interior arrangement to be reviewed. The wheelhouse is always of high interest, since it allows visibility and sightlines to be checked with high accuracy – something that is not possible even with an expensive physical mock-up built inside a factory. For ro-ro vessels, drivers have been able check that they can negotiate ramps and pillars while trying to manoeuvre their trucks around crowed decks. Driver assessed sightlines and two-way traffic can also be tested. Chefs have been checking cooking arrangements of galleys and scientists, the layout of their labs and equipment for sampling and sensor deployment.

Further down the design process, Knud E. Hansen has been working with clients to implement the ShipSpace system to facilitate the review of the final detail design of blocks before they go to production. The system enables multiple users to meet together, similar to video conferencing, except that users are inside the 3D model. Participants can see and hear each other through avatars in a realistic way. It is akin to a site meeting on a virtual ship. This has proven to be an extremely powerful way of conducting design reviews, since people notice details that are easily missed when reviewing on a computer screen. This is largely due to the natural way you view the model with a much larger Field-Of-View (FOV) and stereoscopic vision only possible with an HMD.

If there is an issue with the design, participants can quickly discuss the issue, make measurements, add 3D mark-ups to the model, take photos and voice memos to instruct design corrections. You can even spawn objects to illustrate required changes or pose mannequins to highlight human factor issues. ShipSpace virtual meetings enables reviews to be conducted by participants across different sites, making the review process much faster, and allowing more experts and stakeholders to contribute to the design. The system can also be used by production personnel who would like to familiarise themselves with the design and plan installation sequencing with other labour trades so that people are not getting in

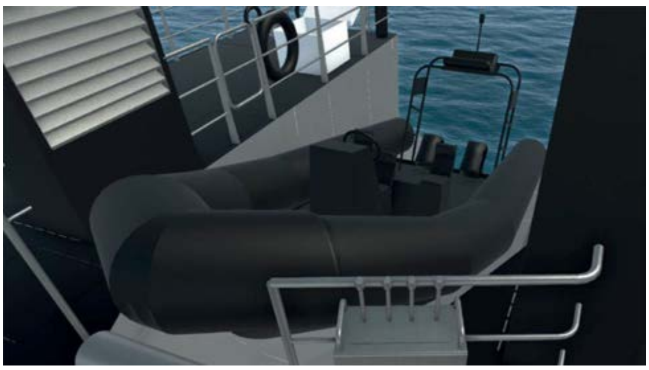


Figure 4: Assessing human factors of tender boat launch and recover

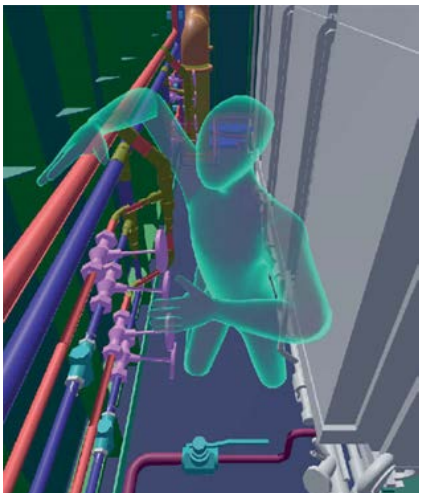


Figure 5: Accessibility for servicing

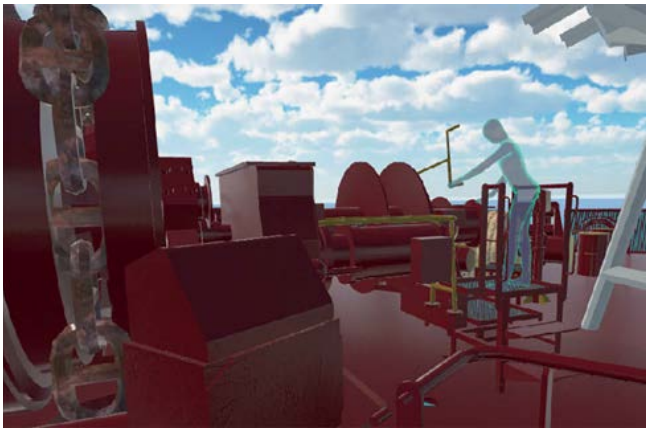


Figure 6: Role playing for redesign of mooring decks

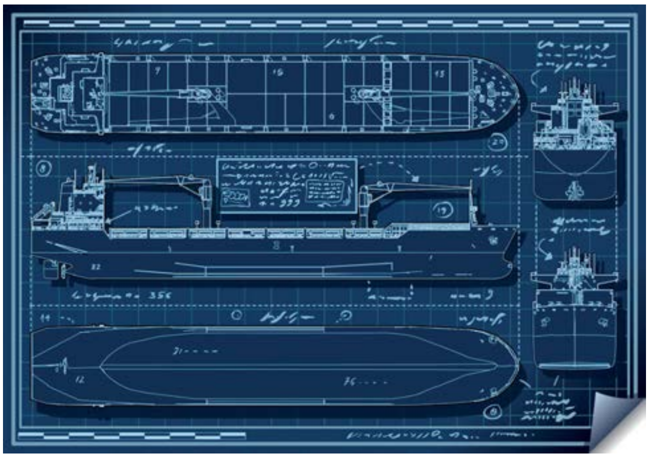
each other's way or causing rework issues.

The company has also assisted in the redesign of existing vessels using the ShipSpace system. For example, where a mooring deck has proven to be too congested and difficult to work in operation, or for retrofit of scrubbers in crowed funnels and casings. As the company gains more experience with working in VR more opportunities for working smarter and more effectively are certain to arise. Goh says: "ShipSpace has been a game changer for us. At the start we only thought of it as a sales tool, but the use cases just seem to keep coming. VR has matured quickly from a fancy toy to a powerful collaboration system for creating better ships more efficiently." *NA*

Conflicting categories of drawings in contracts

Two lists means two sets of obligations, warns Kenneth W. Fisher

Contracts for ship construction or conversion typically contain a series of 'Contract Plans' or 'Contract Drawings' that are listed and identified as essential elements of the contract. However, often there is a second list of drawings categorised as 'Contract Guidance Plans,' 'Guidance Plans,' 'Reference Plans,' 'Information Plans' or some comparable categorisation. Unless the intended use and purpose of the second list is clarified, the identification of two sets of plans or drawings within the contract is a starting point for significant problems. Let's look at the fundamentals of this situation.



Not all plans are created equally. (Image: Shutterstock)

If the rights and obligations of both parties were the same for both lists, they would have been consolidated into a single list of Contract Plans. The presence of two lists of plans in the contract signifies that the contracting parties have different rights, responsibilities and obligations for each list. The problems associated with that second list of plans usually start to develop because the contractor (shipyard) has a different interpretation of those rights and responsibilities for the second list than does the purchaser (shipowner). The contractor cannot know what was in the mind of the owner's technical team when it developed and/or provided the second list of plans unless the intended use of those plans – and how that is different from use of the Contract Plans – has been communicated in the contract documents.

A review of the resolutions of numerous problems arising from the inclusion of two lists of plans within contracts indicates that many different intended uses, or limitations on their use, have been intended, but not well communicated in the contracts. Unfortunately, in many instances this has occurred only after disputes had arisen. There are many possible interpretations of the intended use of such second categories of 'guidance', reference' or 'information' plans that are listed in the contract documents. The wide variation of possible intended uses of that category of plans raises questions that should have been explicitly addressed during contract formation.

1) Is the Contractor is expected to achieve full compliance with the Guidance Plans unless there is an interference between a component shown on the Contract Plans and one shown on the second category plans?
2) Can the Contractor rely on the accuracy and/or completeness of those second-category plans and use them without alteration for the construction or conversion?
3) Can the Contractor rely on those second category plans being entirely consistent with the Contract Plans and Contract Specifications?
4) If used for a ship conversion or repair, can the Contractor rely on those second category plans being consistent with the actual arrangement and condition of the vessel?
5) Does the Contractor have to receive permission from the Owner to vary from the second category plans? ... and if so, is a formal Change Order necessary?
6) If it is necessary to vary from the second category of plans in order to remain consistent with the Contract Plans and Contract Specifications, which party has responsibility to analyse, understand and take responsibility for the operational consequences of the necessary variations?

Those are some, but not all, of the possible interpretations of the intended use of second category plans that are listed in the contract documents. The wide variation of the intended use of second category plans raises questions that need to be addressed when the intended use is not explicitly stated. These problems are generally avoidable if the contract documents describe, in plain and simple words, how the Contractor is to use the plans in that second list, and how that usage is different from the use of the Contract Plans. *NA*

About the author

Dr Kenneth W. Fisher, FRINA, is an author and president of Fisher Maritime Consulting Group Florham Park, New Jersey, USA, which provides project management and consultancy services to the marine and offshore industries, as well as impartial expert witness services. Dr Fisher also provides shipbuilding contract management training services.

Ship and berth interfaces

Significant issues were raised at a joint PIANC-RINA conference held in June at the Institution of Civil Engineers in London, writes Dennis Barber

Having been both a sea serving officer and ship manager I'm intimately aware of the conflicts that can occur between ship and shore at the interface, i.e. the berth. Merchant ships must enter port and berth otherwise they cannot conduct their business so the topic is, or should be, high priority.

Earlier joint RINA-PIANC (World Association for Waterborne Transport Infrastructure) conferences highlighted a clear need for harmonisation between the approaches of naval architects and port engineers and June's event concentrated on some specific areas, namely:

- Ship/Fender interaction issues;
- Fender and Bollard quality issues; and
- Mooring issues.

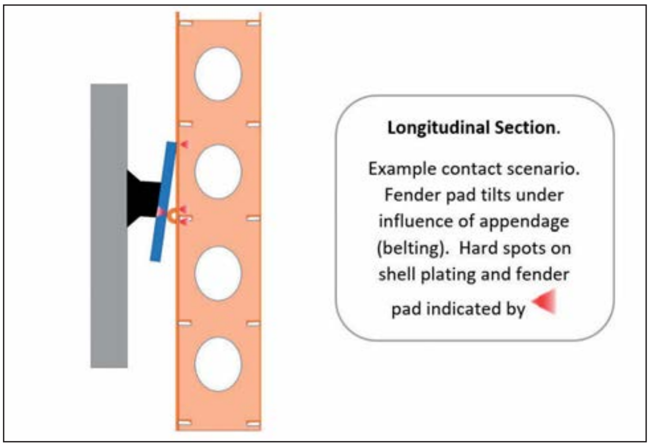


Figure 1: Long. Section Hull with belting/Fender interface

What happens to ship damage from fenders?

A presentation by Steve Osborne of Atkins and Rob Tustin of Lloyd's Register outlined circumstances in which ship side contact with fenders can cause damage. They noted that although science can identify the possibility of inevitable damage the records suggest something different, and delegates discussed the possibility that that conflicts between operational costs versus profit might partly explain this anomaly.

Central records – whether insurance claim records, Class memoranda or even Port State deficiencies (or detentions) – can and often are perceived negatively when charterers or other inspectors call. Any inspector presented with a clean record should, if familiar with normal working wear and tear, be instantly suspicious. A fingertip search of event logs and Class memoranda might reveal more, but the task would probably need a major research project.

Results of analysis being presented did not identify any significant problems with side damage in most vessel types, except for a few cases, but did raise the question of whether the input assumptions were correct.

One case in point is belting – the external structure consisting of stiffened elements naval architects and port engineers differ on their terminology in this area, the former tending to use the term 'rubbing band' and the latter, along with sea serving officers, 'belting'.

During discussion it was pointed out that there were distinctly different types of external appendages in this category, for example, the heavy horizontal belt typically surrounding a ro-ro ferry, which is regarded by ship's officers as built-in fendering. On dedicated routes the port contact points tend to be arranged, usually with vertical piles or other structure to allow the vessel to make contact and move accurately into position on the berth. This type of interface rarely suffers damage other than normal wear and tear and is usually found on dedicated ferry routes.

However, a number of vessel types feature horizontal and sometimes angled stiffening, usually consisting of half round tube, welded to the outer plating. Unfortunately, it is invariably in the contact area for fenders and therefore needs some attention if port visits are to be considered.

Berths are regularly designed with fendering consisting of a number of pads mounted on substantial flexible mounts. The pads are usually designed with a durable surface layer for contact with the vessel side. The surface layer is mounted on a rigid backplate, usually constructed in steel that is attached to the flexible mounts, which in turn are usually flange attached to the jetty, quay face or dolphin (see Figure 1). They are flexible in their absorption of impact and movements but have limitations in their extent of compression or lateral displacement.

This type of fender presents a problem with belting. The fender pad will pivot on the belting such that instead of the entire area contacting the shell plating and distributing loads evenly across it, one of the edges is brought into contact with the shell plating above or below the belting. The entire load on the fender will then be shared between where it pivots on the belting and the contact edge of the fender created by the pivoting. This is much more concentrated than the assumed load pressure spread across the entire fender pad. Damage to both the shell plating and/or appendages and the fender should be anticipated. The belting itself, when of hollow construction, can collapse and even cause damage to the plating at its attachment.

The Osborne/Tustin presentation also identified another special case in large bulk carriers (see Figure 2). These ships are typically single skinned at the central section and stiffened with vertically aligned framing in the transverse configuration. At the same time, the structure above and below the mid-section incorporating spaces usually used for ballast is double skinned and constructed in a longitudinal configuration with horizontal stringers and deep webs and bulkheads. For an arrival at the berth

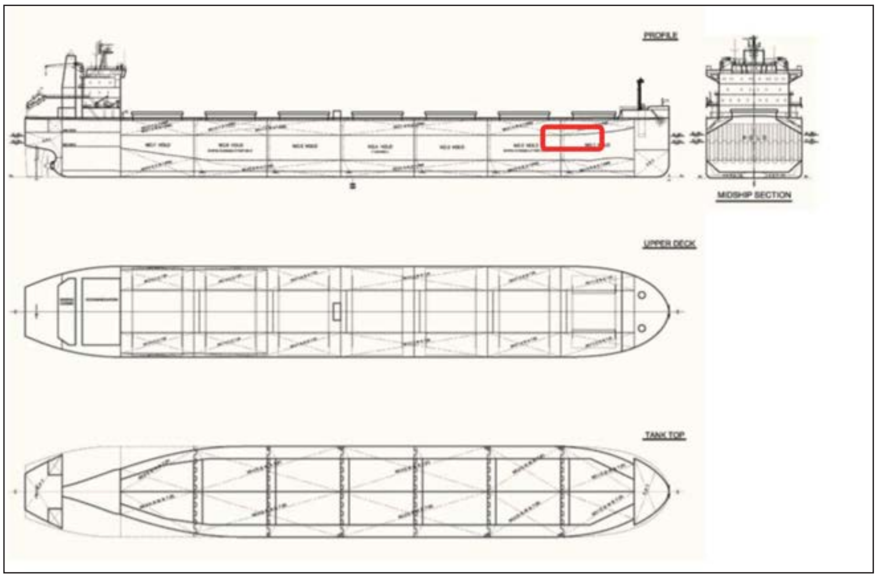


Figure 2: Bulk Carrier (Panamax) Side shell between top and bottom hopper tanks is transversely structured. In tanks the structure is longitudinally stiffened with deep webs at intervals between the bulkheads, which provide the greatest stiffening. Red surround indicates typical first point of contact during ballast arrival

in ballasted condition the fender zone is typically within the mid-section and can therefore present some issues if intensity of forces at fender pads cause indentation (see Figure 2). A particular issue is that of the hard edge created by the join of the differently structured areas, and the possibility of shear failures in the event of deflection and possible yielding of the shell plating.

Deep water ocean side berths

Apart from the well-sheltered traditional ports, large bulk carriers, from Panama size upwards, typically load in deep water ocean side berths that are frequently affected by swell. Yawing induced during ranging (alternating surging of the vessel on the berth) by alternating tensions on forward and aft moorings can introduce repetitious impacts where the berth fenders contact the hull. Berths are frequently constructed as 'T' head jetties and fenders are limited in number, usually mounted on dolphins either side of the jetty, which may or may not itself be fitted with fenders that contact the midship area.

Unlike the sheltered harbour wall, therefore, where the contact with fenders is usually along the hull with short spaces between pads, these jetties will present few contact zones. Consequently, the concentration of loads will be greater and may be repetitious for all or part of the period alongside, creating a scenario for shell plating fatigue.

Push pull

The discussion so far, and certainly in relation to fendering is about the 'push' factor in mooring a vessel at a berth. The compression of fenders will absorb forces from the movement of the hull onto them. They will also possess a spring factor that will, as onset forces and resistance meet equilibrium, reverse the direction of movement of the hull.

The other element of mooring is the ropes that hold the vessel alongside. Whilst in tension these ropes exert forces along their length that translate into forces at the hull. These forces must all be in equilibrium with the offset forces of fenders to achieve a static moored condition.

In the above scenario, in which ranging is induced by swell movement at the berth, the repetitive changing of forces due to the buoyancy of the hull and its inertia will induce variable tension responses in the ropes to the movement of the vessel. This state will exist even when moorings are fixed on braked storage/hauling drums, turned up on bitts and secured on bollards or hooks ashore, especially if the ropes in use are fibre, as opposed to wire, which has much less elasticity but reaches breaking point more rapidly. The effect is an oscillation not only of surge but also yaw as the breast lines and springs increase in tension and pull the bow or stern in towards the berth. This in turn is likely to create an offshore kick that will likely cause the hull to lose contact with the fender (and make contact at the opposite end of the hull).

Conversely, as the hull returns to the opposite yaw on the next oscillation the impact and absorption of force at the fender face will be significant if the considerable mass of the hull (possibly 100,000tonnes) is to have the rotation in yaw checked. The question must be: how much force is concentrated in the small area of the fender contact and what will be the fatiguing factor of the repetitious nature of the oscillations?

Rope strengths

The paper 'Effects of Fibre Rope Stiffness: Behaviour of Mooring Line Tensions', by Stephen Banfield of Tension Technology, was of particular interest in the above discussion. For years, mariners have lived in the relative comfort of knowing that synthetic fibres have increased the strength of mooring ropes and lowered their weight so as to make the mooring more secure. Wire ropes have been extensively used on tankers because of their lower elasticity and the ability to prevent excessive movement on a berth that may threaten the connections carrying polluting liquids. But these ropes are less popular with mooring gangs, both ashore and afloat because of the heavy handling characteristics. The synthetic fibre ropes are easier to handle.

The paper however raised some issues that may not be common knowledge concerning fatigue in these types of ropes and hardening in service, making them more brittle and less absorbing of tensile stress. These issues could create alarm amongst mariners who see the ropes generally as the height of safe mooring practice. The reality may be that the enormous energy stored in the tensioned ropes is a ticking time bomb. It could explain some incidents that I have investigated when synthetic mooring ropes have parted unexpectedly. The blame has usually been put down to chafe, which brings it back to the crew, but also poor mooring deck design. This paper however implies that the variation of the rope strength, generally in a downward direction, may also be cited with more emphasis but it rarely is. More awareness for ship's staff, shore superintendents and designers would help to reduce such accidents.

Shore connection

The conference included a paper with the telling title: 'Why you shouldn't buy bollards at the supermarket', by Chris Bolton of Arup. Recent regulatory improvements onboard ships requiring the testing and marking of bollards has improved seafarer awareness of the hazards lurking in mooring fixtures of suspect strength. The same should apply to shore mooring bollards (and hooks).

As with ropes, mariners have tended to trust designers' calculations for bollards and fairleads. Accidents have occurred however that suggest this trust may sometimes be misplaced. Thinking logically, the progressive increase in mooring rope strength should have been accompanied by a parallel increase in strength of bollards, hooks and winch attachments to decks. Was it? I recall asking the question once as we increased the strengths of the ropes on the capesize bulk carriers we were operating, only to discover that the winches carrying these ropes, that were now reaching 70tonnes breaking strain and more, were attached to the decks with fixtures that had been guaranteed for much lower forces more appropriate for synthetic ropes of the same size of 20 years earlier.

Has the same mismatch evolved on shore? Bolton's paper pointed to the need for proper analysis of forces and the correct testing and installation of appropriate fittings. This is no doubt relatively easily applicable to new berths but are older berths modified to meet changes in the vessels being accommodated?

Conclusion

Like many good conferences, the participants probably came away with more questions than answers. The mix of professional disciplines that attended certainly enhanced the focus groups that debated various aspects of the agenda for the day. It would have been good if more mariners had attended as the practical operations aspect would have benefitted from being informed from direct experience in the full-scale environment.

The working groups established by PIANC are seeking to address the correct topics but, as a port organisation, there is a natural bias towards the civil engineering sector. There is a need for greater involvement from the ship side, both from naval architects and mariners. Perhaps support for future conferences could also include the Nautical Institute and the IMarEST? *NA*

About the author

Capt. Dennis Barber, FNI, MRIN, Assoc.RINA, is former chief marine superintendent of P&O Bulk Shipping, flag and commercial ship inspector, port auditor, risk assessor and expert witness.

An article focusing on bulker-specific side issues will follow in our January 2020 edition.

Uncertainty in lightship data

How a deficiency in the ASTM guidelines for conducting inclining experiments leads to loss of control of lightship data, the basis of stability and loading capacity, writes Prof Colin MacFarlane and Manuela Bucci of Tymor Marine

Lightship is used as the basis for stability assessment and loading capacity so that, by addition of the deadweight, the live load of the ship, is estimated. The lightship weight and horizontal coordinates of the centre of gravity are determined from a deadweight audit, the vertical coordinate of the centre of gravity results from inclining experiments.

2018 and 2019 have seen a lot of travelling for the naval architects of Tymor Marine Ltd in carrying out deadweight audits and inclining experiments. Taking the 'lessons learned' from each of a series of trips onboard vessels, Tymor did a review of the inclining experiment that led both to a paper presented to the Society of Allied Weight Engineers this year[1], where the deficiencies in the traditional inclining experiment and possible solutions are discussed, and developments in the company's MOSIS[2] system. The deficiencies that we feel exist in the traditional approach to ship stability include many aspects that are not discussed further here but a major shortfall is the failure to prescribe calculation of measurement uncertainty, an aspect which could be easily remedied.

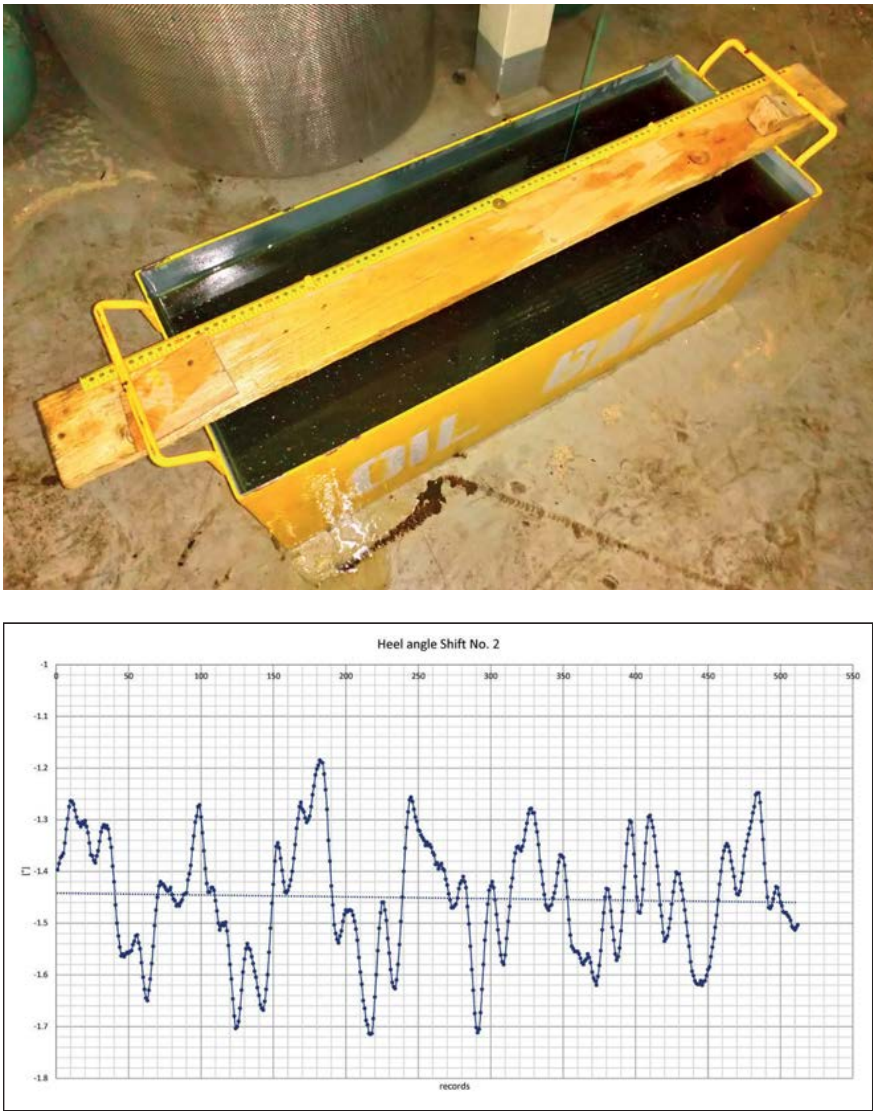
The majority of guidelines for the conduct of the lightship survey and the inclining experiment refer to the ASTM standard F1321-14, where calculation of uncertainty is not mentioned, with the result that in the slow-moving traditionalist world of naval architecture, the concept of stating uncertainty has ended up somewhat lost in the dust and tumbleweed.

Mixed opinions

There is a diversity of attitudes in the industry. Some shipowners and charterers' representatives fully understand and support statements of uncertainty. On the other hand, many others, although understanding the concepts well, prefer mention of uncertainty in the stability test report to be removed because of concern about misunderstanding by others and hindrance or delay in the report acceptance by the authorities. Finally, there are some qualified naval architects who are so unfamiliar with uncertainty that they misunderstand the term itself as an indication of "how poorly" the job of the stability test has been done rather than as an inherent part of the result itself.

It is interesting to observe, however, that some registries (for example, the Croatian and the Russian Registries of shipping - both IACS members) include a dedicated section to the use of uncertainty techniques to assess the acceptability of the measurements recorded at the experiment and the results achieved. At the same time, other registries – in most cases also IACS members –

Figure 1: Comparison of oil bath with no recording facility with the output in minutes of arc of an inclinometer



Measuring incline test	Type of ship	GM at test		VCG at test		VCG Lightship	
		m	%	m	%	m	%
Inclinometers and draught gauges	Drilling Semi	0.071	0.73%	0.137	0.64%	0.879	3.05%
Pendulums and draught marks visual reading		0.150	1.54%	0.150	0.70%	1.031	3.58%
Inclinometers and draught gauges	RoPax	0.014	0.78%	0.063	0.73%	0.501	5.21%
Pendulums and draught marks visual reading		0.216	12.44%	0.396	4.55%	0.676	7.03%
NOTE: The uncertainty in the VCG of the Lightship is heavily influenced by the uncertainty in Deadweight VCG							

Table 1: Comparison of Uncertainty for different Measuring Devices

completely neglect calculation of uncertainty and tend to reject the submission of such calculations for approval of the inclining experiment report.

The objective fact is that the traditional inclining test is one single unrepeated measurement. Without quantification of the associated uncertainty, no assessment can be made of the quality or accuracy of any test. There have been some members of RINA who have discussed such uncertainty in the past few years, as well as case studies that compare uncertainties for different types of vessels (see Woodward et al, 2016[3]); Karolius and Vassalos, 2018[4]) and the desirability of calculations of uncertainty has been expressed in almost every generation of naval architects[5]. In other aspects of naval architecture uncertainty calculations are explicitly required – for example in the ITTC recommended procedures for scale model tests.

We consider the algorithm for the calculation of uncertainty in the inclining experiment presented by Woodward et al. (2016) is simple to use for any naval architect and we do not see any reason why this could be not being implemented in the guidelines and become part of the standard.

A calculation of uncertainty

At the very least, if dealing with dependent and independent variables to further develop Woodward et al.'s algorithm for any case-specific situation seems too challenging, "a calculation" of uncertainty, as used by the Croatian and Russian Registries, should be required. These calculations refer to two standard deviations based on student's t-distribution modelling of metacentric height records calculated from each set of measurement taken at the test – that is eight points in a conventional inclining experiment. The absence, in the rules and standards, of an explicit requirement to include the calculation of uncertainty, together with the lack of homogeneity among class societies, leads to a general "blind" approach to the measurements and unsatisfactory acceptance of one statistical parameter (the mean) without essential, and available, associated information.

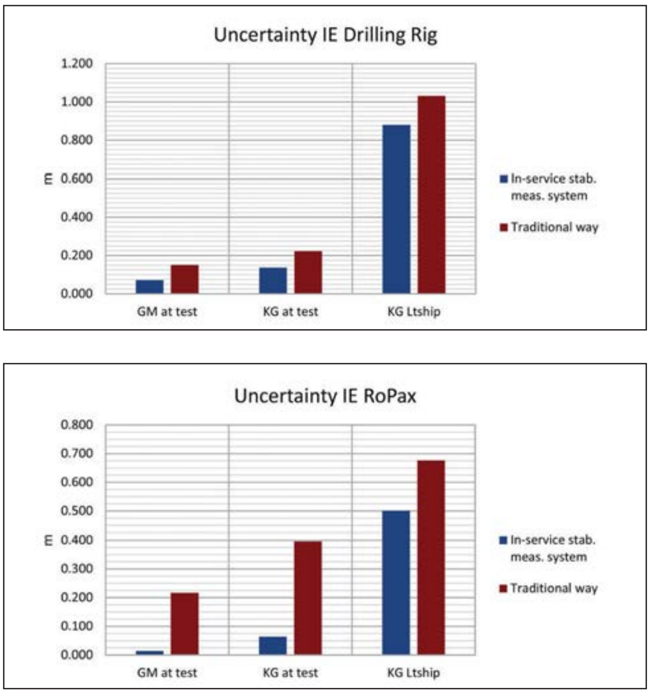


Figure 2: Uncertainties for a ro-pax vessel and a drilling semi-submersible

Other than compliance with the basic physics of measurements – which should itself sound a call to naval architects to adopt an appropriate approach – appreciation and interest to spur such an upgrade in the guidelines and, at the end of the process, in the practice for calculation of the lightship data from an inclining experiment, might be aroused by the concept that uncertainty larger than "normal"[6] for the type of vessel or type of test suggests a result that might lead to a penalty on the loading or potentially leaving a ship unsafe.

The reform of the inclining experiment by a requirement to explicitly calculate uncertainty will, we hope, drive some further developments that appear to be a natural modernisation of the traditions of naval architecture. First, the use of modern electronic instruments to measure heel and other parameters allows

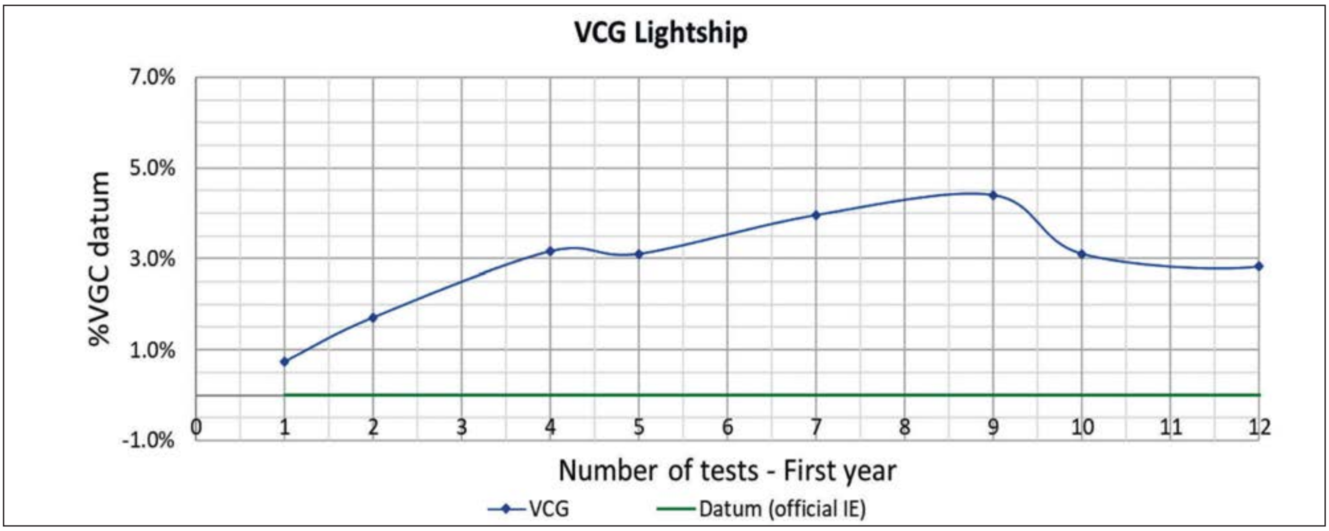


Figure 3: Extract from the first year of in-service measurements. If the formal first inclining experiment (green line) was accurate, repetition in-service (scatter points joined by the blue spline) should have shown, for example, Gaussian variability around this value

storage of time series data records, that can be analysed and post-audited as required. The alternative is to use visually recorded, single values that rely on the experience, skill and concentration of the individual who records the measurement. The archetypical example is represented by pendulums in an oil bath against inclinometers (or angle measurements from IMUs, if used). Consider Figure 1, and consider which measuring system gives outputs that can be audited and post-processed?

The variance of the angle record shows how consistent the vessel's conditions at the test were, and when disturbances occurred. The record can be filtered and averaged with industry standard statistical or signal processing techniques.

The record is saved, and no human mistake can be made during capture, storage and onward transmission. The same considerations apply to measuring tapes against fixed laser measuring units, one-point wind speed measurement against digital anemometers that record and average continuously and, in general, to all the instrumentation used at the experiment.

Table 1 and Figure 2 show the comparison of uncertainties calculated for different measuring devices used at the inclining experiment.

Second, the concept of uncertainty is bonded to the concept of repeatability by the factor $1/\sqrt{N}$, where N is the number of independent measurements taken. This last concept literally shakes the theory of ship stability as traditionally applied: without repeatability of the same result, accuracy cannot be tested. There is, in some sense, repeated measurement in the eight inclinings performed at the test but bearing in mind the discussion of Karolius and Vassalos (2018) even this concept might be re-categorised from being an improvement to accuracy, to being an increase in uncertainty.

As an example, taken from a semisubmersible drilling rig, Figure 3 shows how repeating the inclining experiment over time may lead to quite different outcomes from the formal initial inclining experiment thus highlighting poor accuracy of the latter. While the formal inclining result is fixed over time, the multiple inclinings give different results. If the formal inclining had been correct, one would expect the multiple results to be scattered about the flat line. They are not. Averaging repeated measurements, in this case, would provide a better estimate of VCG for stability assessment. Clearly, repeating the experiment is not practical with the traditional methods, but in-service measurements solve the issue (see https://www.tymor-marine.com/mosis-stability/ for more information).

In conclusion, unless a good reason for not upgrading the inclining experiment by requiring calculation of uncertainty is raised, it would be a positive move if The Royal Institution of Naval Architects (and other relevant institutions) put weight behind this change to IMO and ASTM guidelines and standards. *NA*

Footnotes

1. Bucci, M and MacFarlane, C; "Modernising Ship Stability: Lightship Evolution Diagnostics with In-Service Stability Measurements", SAWE 78th Conference paper No. 3719, 2019. The choice of organisation/venue for the paper was because of links with ABS in the context of in-service stability measurements.
2. Measurement of Stability in Service, invented by Bradley and MacFarlane.
3. Woodward, M. D., Van Rijsbergen, M., Hutchinson, K. W., Scott, A., "Uncertainty analysis procedure for the ship inclining experiment", Ocean Eng., vol. 114, pp. 79–86, 2016.
4. Karolius, K., and Vassalos, D., 2018, "Tearing down the Wall – The Inclining Experiment," Ocean Eng., 148(January), pp. 442–475
5. A very good example of discussion of methods - and criticism of pendulums- from the 1920's is in Tawresey, J. G., 1928, "The Inclining Experiment," SNAME, New York. From the post-war period there is the classic Shakeshober and Montgomery SNAME, New Hampton paper of 1967
6. A further challenge would be to identify criteria for excessive uncertainty in a test that flags the result as "accurate" or "poor".

Sounding a warning on ultrasonic antifouling

Dear Sir,

We receive your publication on a monthly basis and very much enjoy the issues addressed within the industry. However, there is an article that was in the June 2019 issue – '*Is ultrasound the future of biocide-free antifouling systems?*' that we wish to discuss with you. The subject in question is regarding the use of ultra-sonic systems as antifouling systems.

Let me state for the record that even though I work for a very well-established firm that makes this technology I'm not disputing the benefits of ultrasound (U/S) in certain applications. I'd also like to point out that the article does not discredit the effectiveness of copper as an antifouling solution.

There are a few points that we would like you to look into. Firstly, the points regarding the Biocidal Products Regulation (BPR) [that was brought into effect in 2012 and covers the use of biocides products applied to vessels in the EU] are correct, however they imply that impressed-current copper systems fall under the rules of the coatings biocides. This is not the case, the biocide coatings referred to fall under product Type 7, which is the use of paints (i.e. film preservatives) with a very high concentration of copper.

The impressed-current anti-fouling systems (ICAF) fall under Type 11, which are a registered member of the Article 95 list for EU BPR 528/2012. Copper dose rates are not a surface treatment but a volumetric treatment of no more than 25ppb per m^3/h. Most cases the systems are specified to 2ppb per m^3/h and naturally seawater has copper in it at approximately 7ppb.

The ICAF or Marine Growth Protection System (MGPS) – as by law we have to call it – uses the electrolysis principle to create copper ions (Cu+ or Cu++). The ionic form of copper is known to have toxicological effects which at low concentrations result in the inhibition and the settlement of the macro fouling (barnacles and mussels) in larvae form.

The article insinuates that U/S should be a better alternative in regard to futureproofing MGPS, but I would like to bring to your attention that there is no definitive evidence that the use of copper as a Type 11 product will be banned for use within the European Union until there is a clear viable alternative solution.

Furthermore, the majority of the article focuses on the use of U/S on box cooler systems as being a standalone solution to minimise the use of biocides. Yet the photos used in the article would suggest that the testing was done using Weka box-coolers. It is commonly known that Weka coolers use uncoated copper-nickel on the tube stacks. This material is renowned for having antifouling properties, as Cu/Ni leeches copper for a period of time and results in the toxic effect mentioned earlier. Surely if the box-cooler has its own built in antifouling defence of copper then surely the test completed and referred to should be discredited?

At Cathelco/Evac we feel that the use of ultra-sonic systems as a whole is very misunderstood by the industry. We are currently looking into using U/S in niche areas but to do this we have had to examine the product of U/S for its strengths and weaknesses.

This has included internal efficacy, long-term testing and even working with experts in the field to develop new types of application. At this time, in our opinion, there is no actual like-for-like alternative to the ICAF system and we are discovering that the U/S process has many drawbacks.

As outlined above, the issue of the legislation regarding the use of copper has also caused huge confusion in the industry. Copper as a biocide is used in all sorts of things, ranging from medical research to swimming pools. It's the application which is the source of confusion here; we are not a coatings manufacturer, yet the general perception is that we adhere to the same regulations, which isn't the case. *NA*

Yours sincerely
Garry Churm,
MGPS Technical Manager, Cathleco (part of Evac Group)

ADVERTISERS INDEX

If you would like to receive further information on the advertisers featured within The Naval Architect please contact JP Media Services: jpayten@jpmediaservices.com

RINA publications

Books

Please note all prices include postage & packaging

LAMENTABLE INTELLIGENCE FROM THE ADMIRALTY
By Chris Thomas
HMS Vanguard sank in thick fog in Dublin Bay in September 1875 rammed by her sister ship. No lives were lost (except perhaps that of the Captain's dog) but this one event provides valuable insight into naval history of the late nineteenth century. Chris Thomas examines what happened, setting it in the context of naval life, the social and economic situation of officers and ratings. He describes the furore caused by the unjust verdict of the Court Martial, vividly illustrating the joys and trials of the seagoing life in the Victorian era, and the tragic effect on the life of Captain Richard Dawkins and his family.
Price: UK £9.00 EUR £10.00 OVS £12.00
AMAZON PRICE: £12.74

SHIPS AND SHIPBUILDERS: PIONEERS OF SHIP DESIGN AND CONSTRUCTION
By Fred Walker FRINA
Ships and Shipbuilders describes the lives and work of more than 120 great engineers, scientists, shipwrights and naval architects who shaped ship design and shipbuilding world wide. Told chronologically, such well-known names as Anthony Deane, Peter the Great, James Watt, and Isambard Kingdom Brunel share space with lesser known characters like the luckless Frederic Sauvage, a pioneer of screw propulsion who, unable to interest the French navy in his tests in the early 1830s, was bankrupted and landed in debtor's prison. With the inclusion of such names as Ben Lexcen, the Australian yacht designer who developed the controversial winged keel for the 1983 America's Cup, the story is brought right up to date.
Price UK £12.50 EUR £16 OVS £18
AMAZON PRICE: £21.25

THE ROYAL INSTITUTION OF NAVAL ARCHITECTS 1860-2010
Published to commemorate the 150th anniversary of the founding of the Institution, The Royal Institution of Naval Architects 1860-2010 provides a history of the Institution as reflected in the development of the naval architecture profession and the maritime industry over that time. In the book, members give their personal views on the development of their sector of the maritime industry and how it will develop in the future.
Price UK £5.50 EUR £6 OVS £7
NOT ON AMAZON

International Journal of Maritime Engineering (IJME)

2019

Members Part Ref: IJME19 Set Ref: ST19

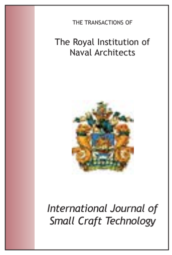
Part A1	Part A2	Part A3	Part A4	Set
£19	£19	£19	£19	£52

Non-Members Part Ref: IJME19 Set Ref: ST119

Part A1	Part A2	Part A3	Part A4	Set
£26	£26	£26	£26	£85

IJME - is published in March, June, September & December. The IJME provides a forum for the reporting and discussion of technical and scientific issues associated with the design, construction and operation of marine vessels & offshore structures

International Journal of Small Craft Technology (IJSCT)



2019

Members Part Ref: IJSCT19 Set Ref: SS19

Part B1	Part B2	Set
£19	£19	£33

Non-Members Part Ref: IJSCT19 Set Ref: SS119

Part B1	Part B2	Set
£26	£26	£46

IJSCT - is published in June & December. The IJSCT provides a forum for the specialist reporting & discussion on technical & scientific issues associated with research & development of recreational & commercial small craft.

Each month RINA offers up to 50% discount on the normal price of its publications. Please visit the website at

www.rina.org.uk/bookshop-bargains

to see this month's specials.

Journals

THE NAVAL ARCHITECT

quarterly publication OFFSHORE MARINE TECHNOLOGY

bi-monthly publication WARSHIP TECHNOLOGY

Published 10 times a year

- Providing up-to-date technical information on commercial ship design, construction and equipment.
- Regular reports on centres of shipbuilding activity worldwide.
- Comprehensive, technical descriptions of the latest newbuildings.
- News, views, rules & regulations, technology, CAD/CAM, innovations.

2019 Subscription

12 months	Print only†	Digital Only*	Print + Digital
UK	£196	£196	£250
Rest of Europe	£205	£196	£258
Rest of World	£220	£196	£274

†Incudes p+p
*Inclusive of VAT

SHIP & BOAT INTERNATIONAL

Published 6 times a year

- In depth coverage of small craft/small ship design, building & technology.
- Specialist sections include: fast ferries, tugs, salvage & offshore, patrol & paramilitary craft, coastal & inland waterway vessels, pilot boats, propulsion and transmissions.
- Advances in construction materials, electronics, marine equipment.
- Contract news and the latest market developments.

2019 Subscription

12 months	Print only†	Digital Only*	Print + Digital
UK	£144	£144	£176
Rest of Europe	£152	£144	£185
Rest of World	£174	£144	£206

†Incudes p+p
*Inclusive of VAT

SHIPREPAIR & MAINTENANCE

Published Quarterly

- In depth coverage of all aspects of shiprepair and conversion work and comprehensive technical descriptions of major conversion projects.
- Regular regional surveys on the major shiprepair centres.
- Developments in shipboard and shipyard equipment technology.
- Contract news, appointments, industry views, new regulations.

2019 Subscription

12 months	Print only†	Digital Only*	Print + Digital
UK	£67	£67	£88
Rest of Europe	£73	£67	£95
Rest of World	£81	£67	£104

†Incudes p+p
*Inclusive of VAT

RINA publications

Conference Papers

If USB format is required please add USB after the reference number.

		Non-Members	*Members*
2019	**Power & Propulsion Alternatives for Ships 2019** Ref: PPA19	£140	£120
	Design & Operation of Wind Farm Support Vessels Ref: WFV19	£140	£120
	Propellers – Research, Design, Construction & Application Ref: PRO19	£140	£120
	Design & Operation of Passenger Ships Ref: PASS19	£140	£120
2018	**Smart Ship Technology 2018** Ref: SST18	£135	£115
	SURV 9 - Surveillance, Search and Rescue Craft Ref: SURV918	£135	£115
	Damaged Ship IV 2018 Ref: DS18	£140	£120
	Warship 2018: Procurement of Future Surface Vessels Ref: WS18	£140	£120
	Human Factors 2018 Ref: HF18	£140	£120
	Full Scale Ship Performance Conference 2018 Ref: FSSP18	£140	£120
	International Conference on the Education & Professional Development of Engineers in the Maritime Industry 2018 Ref: EDU18	£140	£120
	Historic Ships 2018 Ref: HIST18	£140	£120
	Design, Construction & Operation of LNG/LPG Ships Ref: LNG18	£140	£120
2017	**Power and Propulsion Alternatives for Ships** Ref: PPA17	£135	£115
	Pacific 2017 Ref: Pacific17	£135	£115
	ICCAS 2017 Ref: ICCAS17	£135	£115
	Influence of EEDI on Ship Design and Operation Ref: EEDI17	£135	£115
	Warship 2017 Ref:WS17	£135	£115
	Design and Construction of Super and Mega Yachts Ref: MSY17	£135	£115
	Design and Construction of Wind Farm Support Vessels Ref: WFV17	£135	£115
	Smart Ships 2017 Ref: SST17	£135	£115
	Warship 2017: Naval Submarines & Unmanned Underwater Vehicles Ref: WS17	£135	£115
	Design & Construction of Wind Farm Support Vessels 2017 Ref: WFV17	£135	£115
	Smart Ships Ref: SST17	£135	£115

For more information on previous conference proceedings or a publications catalogue, please contact the Publications department on: Tel: +44 (0) 20 7235 4622, Email: publications@rina.org.uk or Website: http://www.rina.org.uk

PRIVACY
Personal data held by RINA will only be used in connection with RINA activities, and will not be passed to third parties for other use. Full details of RINA's Privacy Policy are available online.

☐ I wish to receive information on technical developments in or related to the maritime industry and on future RINA events. I understand that I may stop receiving such information at any time.

Payment Details: Payments must be made in pounds sterling to **RINA** by sterling cheque drawn on a UK bank, International Money Order or Credit Card, we accept Visa, Mastercard, or AMEX.

I enclose a cheque for ____________________ payable to RINA.

Please charge my Credit Card No: ____________________

Expiry date: __/__/__ Security code: _____ Signature: ____________________

Print name: ____________________

Name: ____________________

Address: ____________________

Country: ____________________ Postcode: ____________________

Tel: ____________________Fax:____________________Email:____________________

Please allow 30 days for dispatch and delivery. Post to:

The Publications Department, RINA, 8-9 Northumberland Street, London WC2N 5DA, UK.

Tel: +44 (0)20 7235 4622 or **Fax: +44 (0)20 7259 5912.**

ORDER FORM

Please send me the following:

REF Oct 19

REFERENCE	QUANTITY	PRICE
	TOTAL:	

October 15-16, 2019
Wind Propulsion 2019
RINA conference,
London, UK
www.rina.org.uk/events_programme

October 15-16, 2019
LNG Bunkering Summit: Mediterranean
International conference,
Barcelona,
Spain
www.lng-bunkering-mediterranean.com

October 16-19, 2019
Indonesia Maritime Expo
International exhibition,
Jakarta, Indonesia
www.maritimexpo.co.id

October 22-25, 2019
Kormarine
International exhibition,
Busan, South Korea
www.kormarine.net

October 23-25, 2019
Contract Management for Ship Construction, Design & Repair
RINA conference,
London, UK
www.rina.org.uk/events_programme

November 5, 2019
Marine Industry 4.0
International conference,
Rotterdam,
Netherlands
www.rina.org.uk/events_programme

November 5-8, 2019
Europort 2019
International exhibition,
Rotterdam,
Netherlands
www.europort.nl

November 7-8, 2019
ICSOT India 2019
International conference,
Kharagpur,
India
www.rina.org.uk/ICSOT_India_2019.html

November 19, 2019
Safety Techniques Workshop
Training conference,
London, UK
www.rina.org.uk/events_programme

November 19-21, 2019
METS Trade Show
International trade show,
Amsterdam,
Netherlands
www.metstrade.com

November 21-23, 2019
Pacific Marine Expo
International exhibition,
Seattle, USA
www.pacificmarineexpo.com

November 25-26, 2019
ICSOT Indonesia 2019
RINA conference,
Jakarta,
Indonesia
www.rina.org.uk/ICSOT_Indonesia_2019.html

November 25-December 5, 2019
IMO Assembly
International conference,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

December 3-6, 2019
Marintec China
International exhibition,
Shanghai, China
www.marintecchina.com

December 4-5, 2019
Cruise Ship Interiors Expo
International exhibition,
Barcelona, Spain
www.cruiseshipinteriors-europe.com/

January 15-16, 2020
Marine Design 2020
RINA conference,
Cadiz, Spain
www.rina.org.uk/events_programme

January 28-30, 2020
LNG Bunkering Summit 2020
International exhibition
Amsterdam,
Netherlands
www.oilandgasiq.com/events-lngbunkering

January 29-30, 2020
LNG/LPG and Alternative Fuel Ships
RINA conference,
London, UK
www.rina.org.uk/events_programme

February 19-20, 2020
Human Factors
RINA conference,
London, UK
www.rina.org.uk/events_programme

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

March 11-12, 2020
Damaged Ship V
RINA conference,
London, UK
www.rina.org.uk/events_programme

March 18-20, 2020
Asia Pacific Maritime
International exhibition
Marina Bay Sands,
Singapore
www.apmaritime.com

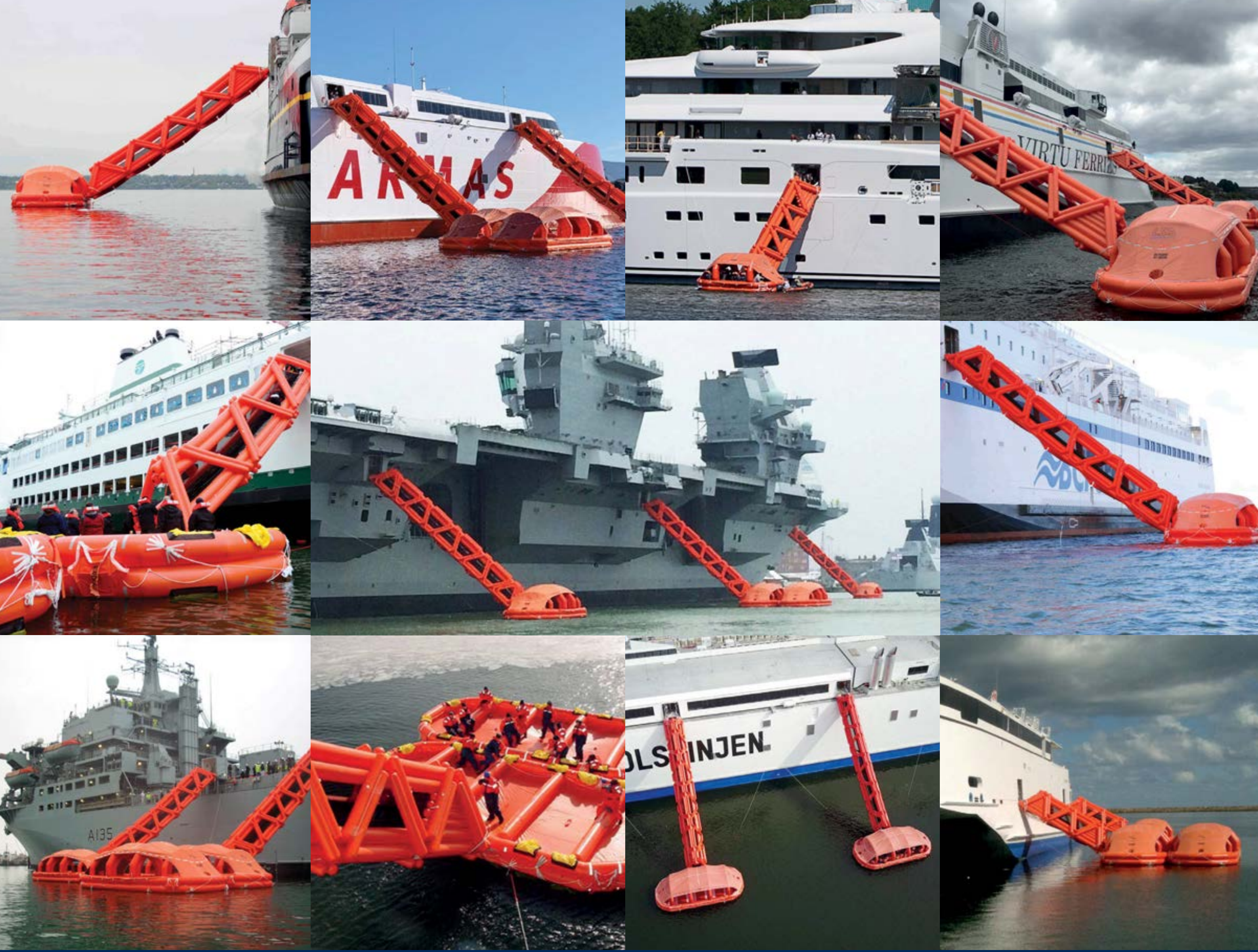
April 1-2, 2020
Autonomous Ships
RINA conference,
London, UK
www.rina.org.uk/events_programme

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

May 2020
Ship and Berth Interfaces
RINA conference,
London, UK
www.rina.org.uk/events_programme

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

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



Simply a better system

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

A: It is simply a better system.

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

Go with the leaders in the industry, reap the benefits and find out what our loyal customers have always known.

LSA MES is: **Simply the BEST system.**

WWW.LSAMES.COM

LSA

LIFERAFT SYSTEMS AUSTRALIA