The Royal Institution of Naval Architects

Wind Propulsion Conference:
Research, Design, Construction and Application

International Conference

Wind Propulsion:

15-16 October 2019

RINA, HQ, London, UK

In Association with:

International Windship Association

Performance predictions of wind propulsion systems using 3D CFD and route simulation

S. Werner, SSPA, Sweden

Accurate performance predictions is a necessary component when designing and optimizing wind propulsion systems (WPS). A trustworthy prediction of the energy saving potential from an independent source is also needed to support the ship owner's decision to invest in new technology.
Using weather statistics along with a mathematical model of ship performance, route simulations can estimate the time and power required for transit of a route. Such simulations are commonly used today, to optimize the design and operation of conventional ships. The introduction of WPS pose additional challenges for route simulations. It is necessary to predict the WPS performance at all points along the route, where the ship will encounter wind of differing velocity and direction. The apparent wind will also vary vertically (twist), due to the interaction between the motion of the ship and the atmospheric boundary layer. In addition, many proposed ship concepts use multiple WPS, introducing additional complexity, such as independent rotor spin ratios/wing sheeting angles.
A 3D CFD simulation captures the complex physics, including vortex formation and interaction effects, providing accurate performance prediction and understanding of the flow. However, such computations are costly and it would not be possible to cover all possible conditions with 3D CFD simulations at reasonable cost.
We present a simplified approach to modelling of WPS, using a limited number of CFD simulations, either in 2D or 3D, which are then extrapolated such that 3D effects are represented and all conditions covered. The methodology is demonstrated on rotor sails and wing sails.

Predicted fuel-savings for a Flettner rotor assisted tanker using computational fluid dynamics

M. Prince and L. Jones, Wolfson Unit M.T.I.A., UK
D. Hudson, University of Southampton, UK
J. Cocks, Shell Shipping and Maritime, UK

This paper presents a case study of the effectiveness of Flettner rotors as a wind-assist device for tanker hull forms. Wind-assisted propulsion is a potential means to achieve significant reductions in Greenhouse Gas Emissions from global shipping, through significantly reducing the thrust required from the propeller and hence reducing engine power and fuel consumption.
In considering the operational effectiveness of any wind-assist device it is vital to look not only at its fundamental aerodynamic performance, but also the interaction between the aerodynamic forces acting and the hydrodynamic forces, together with the wind climate experienced on realistic routes. This complete assessment of performance requires a Velocity Prediction Programme (VPP) approach, as commonly used in the prediction of performance for racing sailing yachts, albeit with the added complexity of the mechanical propulsion provided in the wind-assist case.
In this paper the rotors are modelled using an unsteady Reynold's Averaged Navier-Stokes (RANS) computational fluid dynamics (CFD) approach. A sensitivity to parameter changes such as aspect ratio, diameter and rotational velocity is undertaking, including modelling of the aerodynamic performance in isolation and when positioned on the ship to include rotor-hull interaction effects. The paper discusses the CFD approach in detail, with the challenges and modelling complexities of rotors over non-rotating wind propulsion assist systems highlighted. These studies highlight the potentially significant reductions in aerodynamic performance of the rotors due to both self-interaction and interactions with the ship superstructures compared to performance in isolated, ideal conditions.
The integration of the results into a velocity prediction (VPP) approach is discussed and the potential power savings expected in realistic operation presented. Although the predicted overall power savings are decreased through the aerodynamic interaction effects, Flettner rotors likely remain one of the most promising devices in practice for the immediate reduction of Greenhouse gas emissions from shipping.

Wind Assisted Propulsion Systems and the role of a Ship Classification Society

U. Hollenbach, DNV GL, Germany

Recent IMO regulation require attention for greener shipping. One of the options reducing the emission of green-house gases and fulfilling ever stricter requirements are to use the wind as source of supplementary energy.
Among ship owners there is an increasing interest about the chances and possibilities of wind assisted propulsion. As an independent third-party consultant, DNV GL provides dedicated studies on

- Comparing the performance, reliability and economic impact of different sailing rig concepts
- Comparing the reduction of green-house gases on different shipping routes throughout the year

Principle results of two different studies are presented in this paper.
Wind propulsion and the effect on the EEDI
Each newbuilding must fulfill mandatory EEDI limit values. Wind propulsion systems can become a significant measure to fulfill future stricter limits.
Wind assistance systems are considered in the energy efficiency design index (EEDI). The EEDI describes the CO2 emission of a ship related to its transport work. Installing wind propulsion systems reduces the amount of CO2 emissions, so that for the same transport work a better EEDI is obtained.
The assumptions in the EEDI rule set regarding a "global wind matrix" with reference to the "global shipping routes" is explained and discussed. The force matrix of the ship specific wind propulsion system as a function of the ship's speed may be determined from model testing, land-based full-scale tests or CFD calculations. Based on experience as EEDI verifier DNV GL is prepared to approve the force matrices of different wind assistance systems and to verify the contribution to the EEDI calculation.
Certification of wind propulsion systems
DNVGL has traditionally been dealing with certification and engineering of sailing rigs and uses these synergies for offering certification and engineering services within the wind propulsion segment.
DNVGL has recently developed a technical standard for wind assisted propulsion systems. Additionally, a new additional class notation for the ships carrying such devices has been developed.

Ship data driven propulsion models & wind-based propulsion technology

J. Buckingham, D. Pearson and E. Storey, BMT Global, UK

The availability of AIS and other onboard ship data has opened up new possibilities with respect to the development and application of active ship propulsion models. Such models mimic the parametric behaviour of the propulsion system at regular time intervals. Both traditional and modern parameter-prediction techniques are used to confirm alignment between the computer model and the ship data for a range of sea voyages in different sea states. Wind-based technologies may appear to be a panacea for free propulsion, but the world's oceans do not always experience wind of appropriate speed at the right heading relative to the ship. Key operating areas and routes are identified for the successful operation wind-based energy saving technologies (EST). The VTAS project has combined large publically-available metocean datasets with onboard performance data to build the best possible model definition for a specific vessel and the seagoing conditions experienced on a specific voyage. Vessel modelling has achieved alignment for several ships across a range of ship types. An aligned ship model can then be used to undertake retrospective analyses of actual ship operations with the addition of single EST or combinations thereof such as Flettner rotors, Wingsails and Turbosails. Examples of these are demonstrated for a 61,000 dwt ship. These technical studies provide the foundation necessary to support a wider techno-economic assessment which allow the feasibility and economic viability of an EST installation to be understood.

Seakeeping and Manoeuvring for Wind Assisted Ships

R. Eggers and A. S. Kisjes, Maritime Research Institute Netherlands, the Netherlands

The Maritime Research Institute Netherlands (MARIN) is continuously working to increase knowledge of wind propelled/assisted vessels and to increase their performance. Published research on the application of Wind Assistance Ship Propulsion focusses almost entirely on the performance. Surely that is fundamental to it being viable commercially in shipping and MARIN is also working in this field. However, ships do not only sail in a straight line in calm seas. In operations ships will encounter seas and need to manoeuvre. Seakeeping and manoeuvring is fundamental in applying WASP successfully in a robust manner. This relates to operability, meeting regulations and ultimately safety. Certainly there is also a feedback into performance. When the ratio of wind-assistance relative to propeller thrust is large, there may be a limit on the minimum ship speed to keep course. The reduced thrust of the propeller gives a lower accelerated flow over the rudder, and so the steering ability decreases. This means, that there may be a limit for the maximum fuel savings using wind assistance in stern quartering wind and seas. As part of background research, MARIN started to analyse methods to assess seakeeping and manoeuvring of ships with WASP and obtained first indications for actual performance. The essential challenge in modelling manoeuvring and seakeeping is to model both the aerodynamics and the hydrodynamics simultaneously in the time domain. MARIN previously did this using controlled winchesi. In the present work this was extended with unique tests with a simplified wind tunnel test section in MARIN's Seakeeping and Manoeuvring Basin. Finally, time domain simulations were conducted. This paper will present the various methods, compare them and show first results for vessels with WASP.

Financing Green Ships: Methodological and Practical Considerations

O. Schinas, Hamburg School of Business Administration, Germany

The issue of financing green ships as well as of financing decarbonization of maritime operations has already attracted the interest of experts from the academia and the industry. Given that there is no sign in the market for higher freight rates for green ships and considering that the operating expenses of green ships are at the same levels of the conventional assets, the inherently higher capital expenses required for green assets deteriorate profit margins and deter investors from relevant outlays. Hence, financial engineering is required in order to make investors indifferent to cost and riveted to the decarbonization aspects of any ship financing project. In this regard, this paper analyzes the impact of regulation on the financial decision making, summarizes research results and presents illustrative cases and structures. The analysis will also consider sharing economy models, such as the 'pay as you save', that perfectly suit solutions involving wind-assisted propulsion, and will also identify risks and ways of mitigating them. Last but not least, the financial models considered are technology-agnostic, i.e. they are not bound to a specific technology, therefore can be used further for the assessment of various investments and technology options.

Performance verification of recent Rotor Sail installations

V. Paakkari, Norsepower, Finland

Norsepower's modern Rotor Sails are pioneering auxiliary wind propulsion for the global maritime industry. The Rotor Sail is a modernized Flettner rotor which has proven its performance in several years of operation in demanding conditions in the pilot project onboard the M/S Estraden, a 9,700DWT Ro-Ro carrier.
Norsepower Rotor Sail was installed on Viking Line cruise ferry Viking Grace in April 2018. Since the installation there has been intensive measurement campaign to verify the savings and provide long term savings potential estimates. In addition, during the first year of operation, various other aspects, such as passenger comfortability, noise, and maneuverability where investigated.
The 109 000 DWT LR2 tanker Maersk Pelican, which is owned by Maersk Tankers, was retrofitted with two Norsepower model 30x5 Rotor Sails in the end of August, 2018. The measurement campaign is completed in the end of August 2019 and results are presented after analysis of the data.
The paper summarizes the key outcomes from the Viking Grace and Maersk Pelican projects including a description and summary of results for the measurement campaigns. Onboard Viking Grace, three separate campaigns were conducted by Norsepower, ABB and NAPA, respectively. . The results of all three are well inline with each other indicating that the annual fuel savings in long term are likely to be close to 300 tons of LNG, which was the original target for the project. Regarding the Maersk Pelican installation, results of measurements performed by Lloyds Register and Norsepower are presented.

Effect of Leeway Angle on Propeller Performance

J .J .A Schot and R. Eggers, Maritime Research Institute Netherlands, the Netherlands

The Maritime Research Institute Netherlands (MARIN) is continuously working to increase knowledge of wind propelled/assisted vessels and to increase their performance. One of the aspects affecting the performance of wind assisted vessels is the effect of leeway angle on the propeller performance. Besides forward thrust, wind propulsion devices also generate a side force which has to be balanced by the hull and rudder. As a result the ship will sail at a non-zero leeway angle. From observations in manoeuvring model tests and sea trials it is known that due to leeway the propeller absorbed power can vary significantly from the straight ahead condition. Apart from this change in the propeller operational point also the propeller behind efficiency can change. It is therefore expected that significant propeller hull interaction effects may occur for vessels sailing even with small leeway angles. Using a combination of viscous flow calculations and captive model tests the main flow features affecting the propeller performance when sailing under a leeway angle are investigated for a twin screw and single screw vessels. It is observed that the changes in mean axial velocity and mean rotation in the wakefield due to a combination of leeway angle and propeller suction can be used to explain the in captive model tests observed trends in propeller-hull interaction coefficients. The found trends in the interaction coefficients are then used to approximate the effects on the behind efficiency of the propeller and propeller operational point for the studied ship types when sailing at constant propeller rotation rate and ship speed.

The influence of a thorough physical model on the payback period of wind-assisted ships

G. Bordogna and N. van der Kolk, TUDelft, the Netherlands

The payback period of a wind-assist technology is a key parameter that determines its economic feasibility, and eventually, its appeal to be widespread adopted by the maritime industry. The amount of time necessary to pay back a capital investment in a certain wind-assist technology directly depends on the cost of the technology, the cost of fuel and the amount of fuel savings that such technology is able to assure once installed on a given ship. An accurate estimate of the achievable fuel savings, therefore, is a key parameter in this decision-making process. In this context, the present work deals with a sensitivity analysis of various physical phenomena proper of wind-assisted ships that, due to their complexity, are often simplified or neglected altogether. In particular, this analysis will be performed for vary degrees of complexity for the modelling of aerodynamic interaction between propulsors. From the hydrodynamic side, the changes to vessel resistance due to heel angle will be explored. Finally, the sensitivity of the vessel modelling to operational constraints such as a limit for heel angle and/or rudder angle is considered. The sensitivity analyses will reveal what the impact of the type of modelling, parameters and assumptions is on the resulting prediction. The analysis will be conducted in terms of the impact on the payback period for wind-assist installations.

99kDW Bulker fitted with the Wind Challenger Sail

N. Onishi and H. Fukushima, Mitsui O.S.K. Lines, Ltd., Japan
I. Aoki, Oshima Shipbuilding Co. Ltd, Japan
K. Ouchi, Ouchi Ocean Consultant Inc., Japan

To reduce the fuel oil consumption of a large merchant vessel drastically, the utilization of the ocean wind power should be considered as an important option for the propulsion power of the vessel. The new concept of the hybrid ship powered by Diesel engine and a brand-new sail named “Wind Challenger“ which is huge, rigid and enclosed (height: 46m, breadth: 15m, area: 690m2) on the front end of upper deck as a propulsor for a ship is proposed in this paper. The sail is made by GFRP composite and have a crescent shape section, and also have a vertically telescopic reefing mechanism and self-rotating mechanism to meet the various wind velocity and direction automatically. The study for the performance of 99,000DW Bulk Carrier fitted with one Wind Challenger Sail is done and it is expected to generate approximate 25□ of forward thrust needed for driving this Bulk Carrier on 13 knots, in case of wind velocity of 15 m/sec abeam. Furthermore, a case study on the performance on the real sea voyage between Japan and East Australia is carried out. In spite of rather weak wind velocity on the voyage route including equator region, about 3-4% of propulsion energy is saved in case of cruising speed of 13 knots.

Future trends in the wind propulsion market – effects of policy, regulation, price and the market – barriers and drivers

G. Walker, Windship Technology, UK

The main driving force away from fossil fuels is GHG and Global Warming and all the consequences. The IMO(International Maritime Organisation) have legislated that on the 1st January 2020 Ship Emissions of Sulphur and Nitrous Oxide must be cut from 3.5% to 0.5%. This however does not address the CO2 matter. The IMO have legislated that shipping must reduce its CO2 emissions by 50% by 2050 over 30 years away! The international body of scientists IPCC who met in Korea last year said CO2 had to be cut NOW. The Ship Classification Society DVN-GL described wind as “an inexhaustible source of fuel with no negative side effects.”

Zero Emissions Sailing Ship —Conceptual Design

K. Ouchi, Ouchi Ocean Consultant Inc., Japan
T. Omiya, Mitsui O.S.K. Lines, Ltd., Japan

When a sailing ship which has large rigid wing sails (for example, the Wind Challenger Sail proposed by the author) runs in a sufficiently windy sea area, the thrust by sails is utilized to not only drive the ship at the proper speed but also to rotate a large underwater turbine at significant speed and torque. The turbine generates electricity which is used for the electrolysis of water to generate hydrogen. The hydrogen is stored using toluene in the form of methylcyclohexane (MCH), which is in liquid form under normal temperature and pressure. MCH is stored in the ship's storage tank as hydrogen fuel. In the case of weak winds when the sails cannot generate sufficient thrust, the MCH is loaded to the dehydrogenation device. Using the hydrogen generated by the device, the fuel cell works and supplies electricity to the electric motor propeller for the ship's propulsion and general service inboard. Thus, the ship can run at a constant speed regardless of wind speed and direction. This sailing ship features large retractable wing sails, a motor-generator commonly used as a turbine generator and electric motor propeller, a water electrolysis device, a fuel cell, and storage tanks for the toluene and MCH. The concept of this ship makes it one of the best candidates for a Zero CO2 emissions ship, because the system is operated by only wind energy and does not require fossil fuels such as oil and gas.

Optimal routing of a wind-powered cargo vessel using ensemble weather forecast data

G. Davies, Waseda University, Japan

This paper presents a novel optimal routing method using Numerical Weather Prediction (NWP) wind-wave fields, created in conjunction with the Wind Challenger Project, a JIP (Joint Industry Project) developing a partially wind powered cargo vessel. The devised algorithm optimizes way-points continuously to form a route that minimizes fuel consumption under a time constraint using the interior point method. The thrust of the hard-wing sail, fuel consumption, and wave resistance are precomputed, referencing the True Wind Speed and Direction, and significant wave height and period.
It is known that the forecast skill of the NWP degrades within 5 days or so, thereby considered to be the largest source of uncertainty in optimal routing for the trans-basin route. The proposed Ensemble Averaging Method (EAM) takes forecast uncertainty into account using the ECMWF ENS-WAM ensemble data set, treating each ensemble member as a randomly drawn sample in a Monte Carlo approximation. The EAM is evaluated against the optimal route found using the control forecast (CNTL), the best single forecast. Analysis data, considered most accurate, is used as a baseline with which to compare.
Simulations, run across 2016 on a trans-pacific route, show the EAM significantly outperforms the CNTL route. An error parameter, measuring the deviation of a route to the optimal route in analysis data, showed a 35% percent improvement when using the EAM. In addition, when comparing in analysis data, both the mean engine power and mean error in arrival time were reduced by 15.97 BHP and 0.23 hours respectively.

Autonomous Sailing Vessels for Short Sea Shipping

A. Chaplin, OneSails, UK

The transport infrastructure of Europe is heavily used. Expanding it is expensive, hard and often slow. The carbon emissions associated with transport need to be reduced. Small Windpowered Autonomous Surface Vessels (WASV) working as coasters have the potential to reduce carbon emissions and return to commercial use some ports that are too small to be economically served by conventional vessels. This project examined the coast of the UK to find a route that may be used to test proof of concept vessels to demonstrate the commercial and functional viability of small WASVs for cargo transport.
Several suitable areas were identified, and one area, the Firth of Clyde, was investigated more closely. For early trials suggestions were limited to currently active ports and cargos investigated were limited to the minor bulk trades, goods that are often shipped in relatively small consignments over fixed routes. A pair of suitable ports, Campbeltown and Troon, were identified and a cargo, round wood timber, was found. In the process of this work other potential cargos and routes were noted that may also prove suitable once the vessels have been developed.
Over the route identified the costs of using road transport, conventional small coasters and WASVs were estimated using a variety of assumptions about their cost and performance. It was found that the cost of using the WASVs appeared to be broadly comparable with the costs of the conventional alternatives, with the advantage of reduced carbon emissions and potentially less intrusive traffic patterns.

Dimensioning, Design, Manufacturing and performance assessment of Oceanwings Wingsail onboard Energy Observer

N. Sdez, VPLP design, France

Based on the experience gained through the design and realization of a first prototype, VPLP design engaged itself in the design and making of wind propulsors called Oceanwings, dedicated to the boat called Energy Observer. The dimensionning, design and making of such a system is documented. The data collected by the embarked calculator during a rough 6 months operation are collected, processed and presented. A comparison is made with regards to models used at design stage, together with a global energy performance assessment.

Retrofitting of Flettner Rotors to reduce Fuel Consumption and CO2 Emissions

M. Vahs, University of Applied Sciences Emden / Leer, Germany

The IMO aims to reduce CO2 emissions of international shipping by at least 50 percent by 2050. In this way, shipping would make a significant contribution to the climate target, even if the IMO remains below the demands of the high ambitious states that want to achieve 70 to 100 percent decarbonisation in this period. Even though many details of the new IMO strategy are still open, it is already clear that new technological approaches are needed. A renaissance of wind energy for ship propulsion seems to be obvious, the high potential at sea is well known. Today's shipping needs technologies that meet all the important requirements of modern ship operation. Flettner rotors have already proven their fundamental suitability in various projects. In June 2018, a German-Dutch project consortium under the scientific direction of the Emden/Leer University of Applied Sciences retrofitted and commissioned the latest rotor development of the "Eco-Flettner" type on the test ship "Fehn Pollux" of the Leer-based shipping company Fehn Ship Management. The retrofitting concept developed by the maritime companies and scientific institutions involved is groundbreaking in terms of easy transferability to other ships. Upscaling to a significant share of the world merchant fleet could make a substantial contribution to climate protection.

The following report is intended to provide information on important aspects of planning retrofits or newbuildings with Flettner rotors and is based on the results of the sea trials and the first phase of testing under normal operating conditions. In order to comply with all existing regulations regarding the use of this new technology, various areas of ship technology and navigation had to be illuminated, e.g. proof of safe manoeuvring characteristics and sufficient stability. The most frequently asked question in connection with modern sail drives, however, is about the performance potential and the associated fuel savings. Transparent performance data are required to enable an economic prognosis for the use of Flettner rotors on ships. The Faculty of Maritime Sciences at Emden/Leer University of Applied Sciences has developed an automatic control and monitoring system for Flettner rotors that also records extensive operating and environmental data. The data show that all previous assumptions and model calculations are basically confirmed. With regard to the performance potential, the first series of measurements show even higher rotor forces compared to the model calculations. This would have a positive effect on the economic efficiency of Flettner rotors and could help the technology to achieve a breakthrough as a building block for low-emission shipping.

Retrofitting of Flettner Rotors to reduce Fuel Consumption and CO2 Emissions

G. van der Bles, CONOSHIP, the Netherlands

The large fleet of Short Sea cargo vessels sailing the NW-European waters from North Sea to Mediterranean, has a large potential for reducing maritime CO2-emissions: the vessels navigate in windy waters at relatively low speed of 10 – 12 knots . Compact Wind Assisted Propulsion units can already provide relevant percentage of savings in fuel and emissions compared to the relatively modest installed engine power, adding up to relevant CO2 reduction because of the large fleet of existing Short Sea Ships. For most vessels the additional wind-driven thrust will be reduced on the propeller thrust tot keep an equal economical speed and reduce the fuel consumption and emissions. For the category of vessels with max 749 kW installed power, for which no chief engineer is required on board for Dutch and German flag-requirements, the extra wind-driven thrust enables the vessel to attain extra speed. In certain trades this can be more economical from logistical point of view, saving time and fuel.

Major challenges for application of Wind-Assisted Propulsion units for these vessels are:

- the small crews on these vessels, for which the systems need to be fully autonomous, not requiring extra attention from the crew;
- avoiding extra resistance in head-winds and influencing maneuverability in ports and heavy traffic area's;
- limitations in airdraft in certain ports and covered (un)loading quay's;
- they should not impede regular loading and unloading of the vessels, that have very large holds that should open (almost) completely for (un)loading operations;

The paper presents the pro's and cons of various solutions and developments of eConowind-units and stand-alone VentiFoils , to find an optimal balance between maximum savings in fuel & emissions, and operational cargo-handling efficiency. Future developments in port-infrastructure will be considered, where 'Green Ports' can distinguish themselves providing services for simple handling and temporary storing of Wind-Assisted Propulsion units.

International Conference

WIND PROPULSION:

15-16 October 2019, RINA HQ, London, UK

To register, simply complete all sections of this form and return it with your payment to:

The Conference Department, RINA , 8-9 Northumberland Street London, WC2N 5DA
TEL: +44 (0)20 7235 4622
FAX: +44 (0)20 7259 5912
E-MAIL: conference@rina.org.uk

TITLE (Dr, Mr, Ms, Mrs, Eur Ing):

NAME (as it should appear on name badge):

POSITION:

COMPANY (as it should appear on name badge):

INVOICE ADDRESS:

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

CONTACT MAILING ADDRESS (if different):

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

PLEASE INDICATE REGISTRATION FEE & METHOD OF PAYMENT:

☐ MEMBER, ☐ NON MEMBER, ☐ CONCESSION, ☐ AUTHOR

I enclose a cheque for: £
(made payable to RINA)

Please send me an invoice for : £

Purchase Order Number:

Bank Transfer details enclosed for: £

Please debit my credit card by: £

Card Number: (Visa/Amex/Mastercard)

Expiry Date: **Signature:**

CVV:

REGISTRATION FEE	By 16/09/19	After 16/09/19
RINA MEMBERS:	£670 + VAT = £804	£770 + VAT = £924
NON-MEMBERS:	£770 + VAT = £924	£870 + VAT = £1044

CONCESSIONS: *(Retired/Students etc.)*	£340 + VAT = £408
PRINCIPAL AUTHOR	£145 + VAT = £174
ADDITIONAL AUTHOR	£670 + VAT = £804

The registration fee includes printed conference papers, lunch, refreshments, a USB of the papers and presentations after the conference.

CONFERENCE PAPERS
Delegates will receive a copy of the conference USB which will include the presentations, this will be posted out around 10-12 weeks after the conference.

Aditional copies of the conference papers will also be for sale after the event in both print and USB versions. If you would like to order copies, please fill in the relevant sections.

I am unable to attend the conference, please reserve me _______ set(s) of Conference proceedings

Papers **£120** (members) ☐ **£140** (non-members) ☐

USB **£120** (members) ☐ **£140** (non-members) ☐

For a full list of the Institution's Conference papers, USB and other technical publications please contact our Bookshop Assistant on +44 (0)20 7235 4622 or via e-mail at: publications@rina.org.uk

PAYMENTS
Payment must be made in pounds sterling by Eurocheque, cheque drawn on a bank with a UK branch address, credit card (VISA/Amex/Mastercard) or bank transfer. Please note RINA requires payment before the conference date.
Account Name: The Royal Institution of Naval Architects;
Account Number: 10042127; **Account Code:** 160016
Bank Address: Royal Bank of Scotland PLC, Belgravia Branch, 24 Grosvenor Place, London, SW1X 7HP, UK.
IBAN No: GB14RBOS16001610042127
SWIFT No: RBOSGB2L

*VAT: VAT will not be charged on any cancellation fee issued irrespective of the country the delegate resides in. Delegates from outside the UK may be entitled to reclaim this cost.

VENUE
The venue for the conference is: RINA HQ, 8-9 Northumberland Street, London, WC2N 5DA, UK

EVENING DRINKS RECEPTION
Following the end of the day (27/03/19), delegates are invited to attend an afternoon drinks reception at the conference venue.

ACCOMMODATION
Upon registration you will be provided with details of a hotel booking service offering reduced rate accommodation for conference participants.

CONTINUING PROFESSIONAL DEVELOPMENT
RINA Certificates of Attendance will be issued at the event, which contributes towards the Institution's Continuing Professional Development Scheme. For further details regarding the scheme please contact Giuseppe Gigantesco, Director, Professional Affairs on Tel: +44 (0)20 7235 4622 or e-mail: membership@rina.org.uk

STUDENT SPONSORSHIP
A number of sponsored places at this conference are available for Student Members of RINA. For more information, please contact Nick Cox, Professional Affairs, RINA on Tel: +44 (0)20 7235 4622 or e-mail:ncox@rina.org.uk.

PROMOTIONAL OPPORTUNITIES
Why not use this conference to promote your company's products and services? It provides an excellent opportunity to increase your profile and to network with a highly focused audience. We offer a number of cost effective options, including various conference sponsorship packages, exhibition space and literature distribution. If you are interested in any of these promotional opportunities please contact John Payten at JP Media Services, jpayten@jpmediaservices.com to discuss your individual requirements.

CANCELLATION CHARGES
Cancellations received in writing two weeks before the event takes place will be subject to administration charge of £200. Cancellations received after this time cannot be accepted and are subject to the full event fee. Delegates may be substituted; however, this must be sent in writing and confirmed with the conference Co-ordinator. It may be necessary for reasons beyond our control to alter the content and timing of the programme. In the unlikely event that RINA cancels the event for any reason, our liability is limited to the return of the registration fee.

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.

If you have any questions regarding this or any other RINA event please contact, our Conference Organiser on:

Tel: +44 (0)20 7235 4622 **Fax: +44 (0)20 7259 5912**
E-Mail: conference@rina.org.uk **www.rina.org.uk/events**