1-25

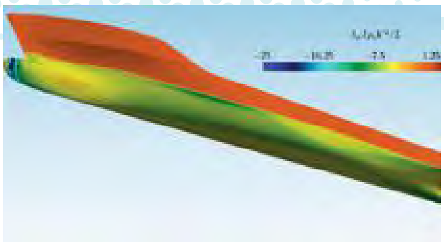
HSVA newswave

The Hamburg Ship Model Basin Newsletter

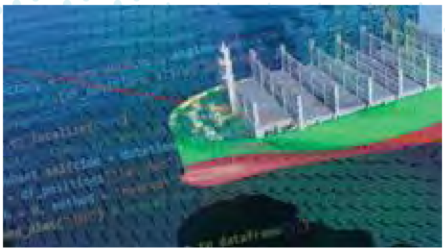
Aerodynamic Configuration Optimisation of Flettner Rotors for a Tanker

Photograph of ANNIKA BRAREN (copyright@Daniel Heimhold, Leer)

Adjoint Simulation Methods for Optimisation Purposes



Full-scale Performance Verification Turning Data into Information



Ship-Ice Interactions How to Optimise Hull Shapes

Dear reader,

It is a great pleasure for me to present this NewsWave issue in my current role as Interim Managing Director of HSVA. This is an exciting time for our company with the completion of significant projects paving the way to HSVA's future.

It has always been part of HSVA's core objectives to increase efficiency of ships and thus to reduce their environmental footprint. Taking this seriously, we are also committed to achieve the same for our own operations. For instance, HSVA has installed Hamburg's second largest photovoltaic plant on the roof of our towing tank, delivering a maximum output of up to one megawatt of renewable power for our testing facilities.

While model tests in HSVA's facilities deliver a reliable prediction for the speed-power performance of vessels prior to the commissioning, assessment of in-service performance delivers valuable insights into the performance of vessels in operation. Drawing the right conclusions for decision making does not only require the collection of data in sufficient quality, but also the right technology for data evaluation and analysis. Have a look at our article about full scale performance assessment!

At HSVA, our mission to reduce the industry's environmental impact does not stop at the energy demand of vessels. Also shipborne noise is nowadays recognised as being harmful to aquatic life. HSVA performs hydroacoustic measurements in HyKat in order to quantify and to improve noise emissions from propellers as our colleagues report.

Besides emissions safety of shipping must not be left aside. In order to assist crew and pilots in ship handling, manoeuvring data need to be determined and documented on board of vessels. HSVA assists with advanced numerical tools and model tests to provide reliable data to the crews.

And there is much more innovation in the NewsWave at hand. Our exploration of new technologies continues, as highlighted by reports on wind-assisted propulsion, advanced CFD-methods, numerical ice simulation, and our new research project, SMiLLA. Be inspired!

Finally, it is my pleasure to welcome HSVA's new Managing Director, Dr. Philip Augener, who has just joined the team beginning of April. In this issue, we have the privilege of presenting an interview with him, where he introduces himself and outlines his ideas for the future direction of HSVA.

I hope you enjoy reading this issue and remain with

warm regards,

Dr. Florian Kluwe
Interim Managing Director

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Herausgeber / Editor
Hamburgische Schiffbau-Versuchsanstalt GmbH
Bramfelder Straße 164
D-22305 Hamburg
Tel.: +49-40-69 203-0
Fax: +49-40-69 203-345
www.hsva.de

Konzept / Concept
adMeyerART
Schwenckestraße 16
D-20255 Hamburg
Tel.: +49-40-646 64 581

kontakt@admeyerart.de
www.admeyerart.de

Druck / Printing
WIRmachenDRUCK GmbH
Mühlbachstraße 7
D-71522 Backnang
Tel.: +49-711 99 59 82-20
Fax: +49-711 99 59 82-21
info@wir-machen-druck.de
www.wir-machen-druck.de

Introduction of the new Managing Director of HSVA Dr. Philip Augener

Dear reader,

after starting my position as managing director of HSVA on April 1st, 2025, I would like to introduce myself and my ideas for the next chapter of HSVA.

My name is Dr. Philip Augener, and I was born in 1981 in the city of Essen, Germany. At the age of four I moved to Wilhelmshaven on the coast of the North Sea, where I developed my passion for the sea.

Based on this, I decided to study Naval Architecture at Hamburg University of Technology (TUHH). After my diploma I started working at the Institute of Ship Design and Ship Safety at TUHH, where I graduated with my doctoral thesis on "Computation of Wave Drift Forces for Dynamic Positioning in the Early Design Stage".

Following my time at the university I wanted to work at a shipyard and was given the chance to make that plan a reality at Abeking & Rasmussen Schiffs- und Yachtwerft SE in Lemwerder. I started working there in the ship theory department and continued as project manager design division. Overall I worked for almost ten years at the shipyard.

Thereafter, I moved back to Hamburg and took over a position as project engineer for offshore grid connection systems and converter platforms at Amprion GmbH.

Recently my strong passion for ship technology and hydrodynamics lead to the decision to apply as managing director of HSVA and I am very proud and honored to have been appointed to this position.

I am convinced that sustainable shipping is meaningfully based on optimised hydrodynamics, while this always has to be considered in combination with ship safety. This is a complex and interesting task.

HSVA is a very important player in this area and I am eager to drive innovative solutions forward together with the HSVA team and partners and make them available to the market.

How do I envisage the future of HSVA?

Well, for me there are three key aspects for the successful future of HSVA:

Excellence, High Tech and Teamwork!

With our fantastic facilities HSVA must always be seen as great service provider for model testing for various ship types and maritime structures. In addition HSVA is a strong partner for maritime consulting and a key driver in maritime research, especially for all hydrodynamic questions.

We will continue to permanently improve our technologies and our know-how to provide the best services. In order to accomplish this task, we have to further develop HSVA as a modern, lean and digital company.

I am looking forward to welcome you here at HSVA!

Yours sincerely

Dr. Philip Augener
Managing Director

Possibilities of Adjoint Simulation Methods for Optimisation Purposes

International shipping is responsible for the transportation of around 80-90 % of global trade. The dominant role of shipping is due to the low fuel consumption per ton-kilometer of transported cargo. However, the sheer size of around 55-60 thousand merchant ships in operation puts economic and environmental aspects of shipping at the center of regulatory interventions and numerous optimisation efforts. Therefore, reducing the power requirements of ships even by a few percent is of great value from an economic and ecological point of view. In addition, efforts to shorten development times are increasingly placing simulation-based approaches at the center of industrial process chains.

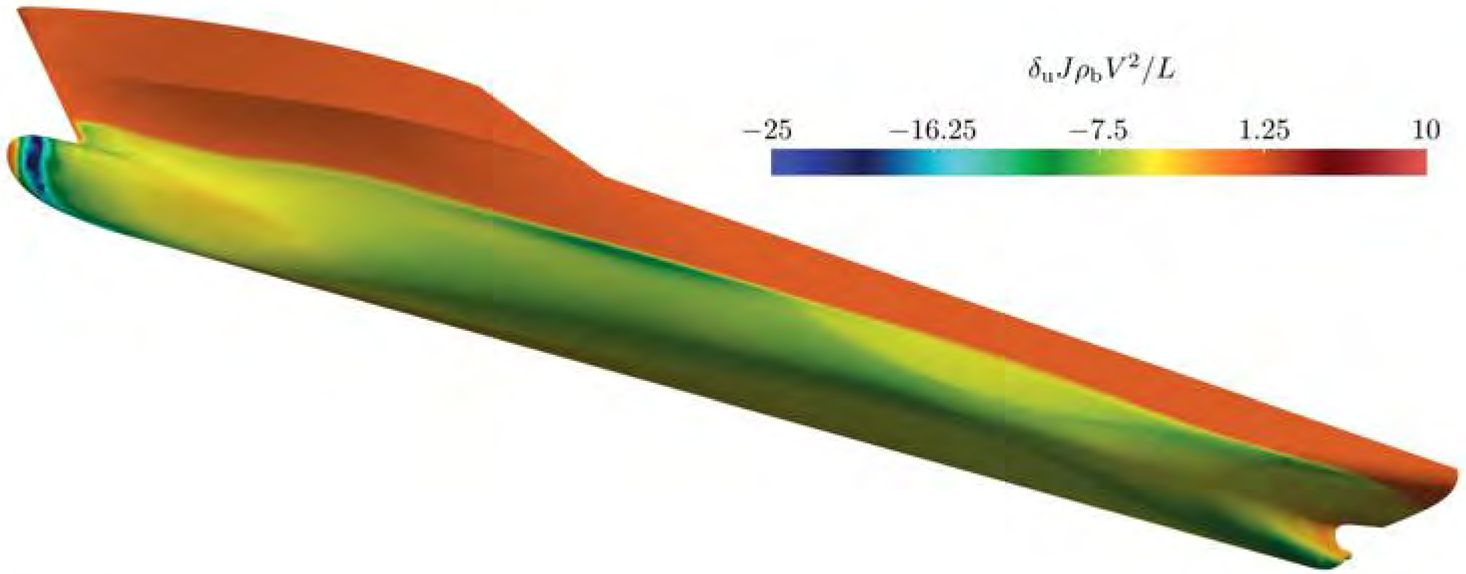


Figure 1: Exemplary sensitivity maps of a container ship (top) and a bulk carrier (bottom).

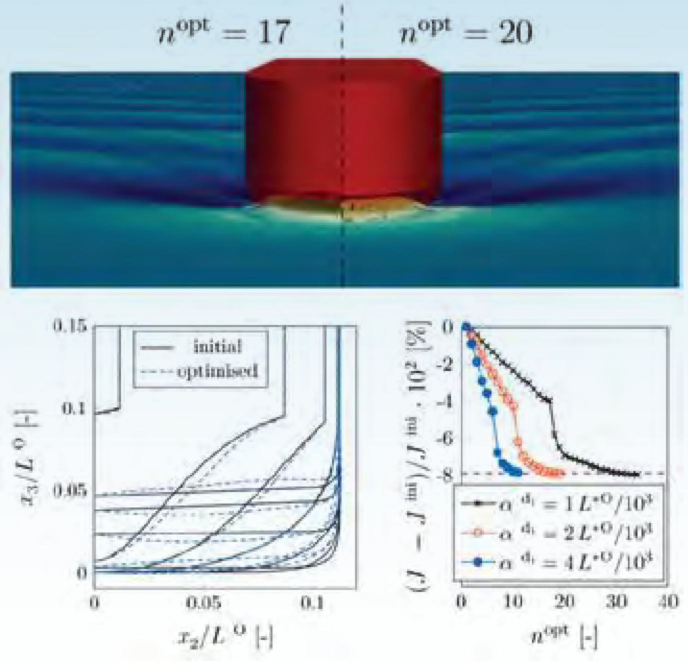


Figure 2: Results of a fully automated shape optimisation of an offshore supply vessel through successive grid morphing with different step sizes.

by Niklas Kühl

Alongside theory and physical experiments, simulation-based science forms the third pillar of today's scientific organisation. Focusing on the third pillar, HSVA is participating in a current research project (Propulsion Optimisation of Ships and Appendages, ProSA) funded by Germanys Federal Ministry of Economics and Climate Protection. The viscous Reynolds-Averaged Navier-Stokes (RANS) solver ***FreSCo+*** refers to HSVA's Computational Fluid Dynamics (CFD) workhorse, which is equipped with various technical features relevant to the maritime industry's demands. However, its unique selling point is the presence of an adjoint CFD module, which allows the efficient calculation of parameter-free shape sensitivities. The root of adjoint-based optimisation refers to the mathematical calculus of variations, especially its application to flow variables (pressure, velocity, etc.). In order to obtain gradient information, e.g., of the flow-induced resistance with respect to unparameterised industrial ship hull shapes, the corresponding adjoint state of the CFD simulation is required. HSVA's aim of the ProSA project is the standardised use of the adjoint solver in industrial projects. In this context, important aspects such as numerical robustness or CAD to CFD coupling are central to the technical objectives.

An exemplary result of an adjoint ***FreSCo+*** resistance simulation is given by a sensitivity map along a ship's hull, see Figure 1. The numerical tool provides the designer with a color-coded suggestion of areas in which an increase or decrease in displacement has a positive effect on the ship's performance. This information is provided entirely computer-aided, fully automated, and is particularly attractive for hull shapes already optimised by humans, e.g., experienced designers. In various recent industrial projects, the adjoint CFD solver improved the performance of pre-optimised shapes by several percent.

Technical shapes theoretically feature infinite degrees of freedom. However, predefined, e.g., CAD parameters are used in industrial applications to describe the shape, corresponding to narrowing the space of all possible shapes but initially making optimisations in this parameterised subspace more accessible. On the other hand, parameter-free shape optimisations do not restrict the shape space a priori. They are based on the incrementally progressive deformation of a technical shape and the associated body-adapted spatial discretisation. In addition to the optical evaluation of the sensitivity map from Figure 1 by manual adjustment of relevant CAD parameters, there is also the possibility of purely CFD-based shape optimisation. In this context, repeated primal and adjoint simulations are carried out for approximately 20-50 shape modifications to identify the local optimum. The approach is based on an efficient grid-morphing strategy that requires no re-meshing during the shape evolution.

The following Figure 2 gives an impression of exemplary results of such targeted, local optimisations and impressively demonstrates the possibilities of the currently developed method.

contact: kuehl@hsva.de

This project is funded by the German Federal Ministry for Economic Affairs and Climate Action.

Federal Ministry for Economic Affairs and Climate Action

Aerodynamic Configuration Optimisation of Flettner Rotors for a Tanker

the Project Ship in FlettnerFLEET

Photograph of ANNIKA BRAREN (copyright@Daniel Heimhold, Leer)

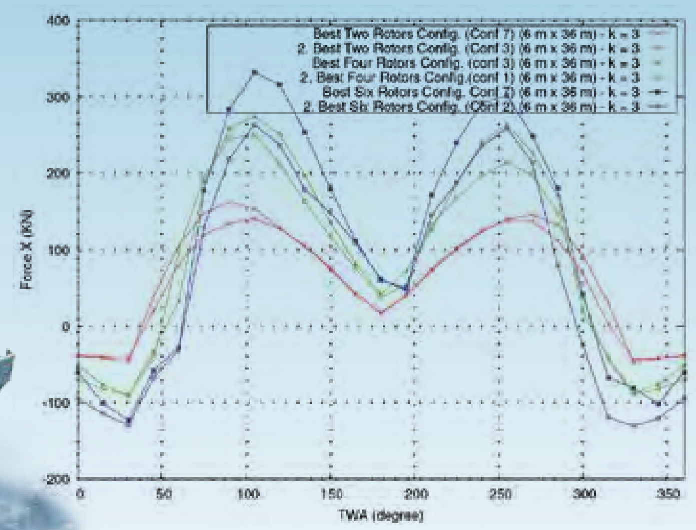


Figure 2: Calculated total thrust of Rotors running at spin ratio 3 for the two best configurations with two, four and six rotors respectively.

Wind (assisted) propulsion is the most promising way forward in the maritime industries strive to meet emission reduction targets for the coming years.

by Yan Xing-Kaeding and Niklas Kühl

This particularly holds, given the cost associated with emission-free propulsion solutions. Whilst numerous technologies promising significant gains in efficiency and emission reductions are entering the market, full integration of wind propulsion solutions into an overall (holistic) ship design process remains sparse.

In the German Federal Ministry of Economic Affairs and Climate Action-founded research project FletterFLEET, HSVA plays an important role in providing both aerodynamic and hydrodynamic analyses for optimised wind-assisted propulsion solutions. Within this project, HSVA has developed a fully automated numerical parametric pre/run/post-simulation process to design integrated wind propulsion solutions for new buildings or retrofits. Computational Fluid Dynamics (CFD) analysis is used together with parametric geometry and topology modelling to optimise the configuration of Flettner rotors on different ship types in close combination with other relevant elements of the ship superstructure and the hydrodynamic aspects, cf. NewsWave 1-23.

Given the characteristics of the huge matrix of aerodynamic relevant parameters such as apparent wind angles and wind speed (combination of the true wind angles, true wind speed, and ship speed) as well as rotors' on-off scenario and spin ratios, a simulation-driven process with short response time for evaluating rotor configurations is essential. Therefore, a frictionless simulation method utilising an Eulerian flow analysis featuring a state-of-the-art, massively parallelised second order Finite-Volme-Method has been employed. A severe reduction in simulation time can be achieved compared to viscous modelling and simulation approaches based on, e.g., Reynolds-Averaged Navier-Stokes (RANS) methods, scale-resolving Large-Eddy-Simulation (LES), or hybrid combinations. The implementation is then verified against analytically solvable academic test cases and validated against both high-fidelity, scale-resolving simulation results of a real Flettner rotor installation on a general cargo vessel "Annika Braren" cruising in the Baltic Sea (see Figure 1) and two rotor interaction test cases from wind tunnel tests with satisfactory agreement.

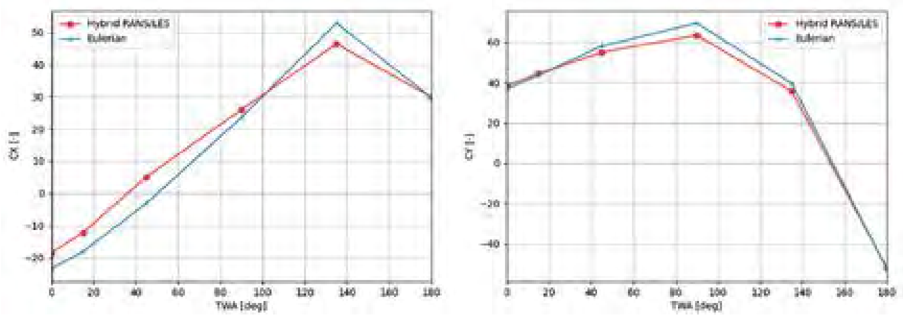


Figure 1: Comparison of calculated non-dimensional total forces between Eulerian and Hybrid RANS/LES simulation methods in longitudinal (left) and lateral direction (right) over the true wind angle.

Subsequently, the presented method has been applied to the aerodynamic investigation and topology optimisation of rotor dimensions and positions on the deck of a tanker. Whereas certain areas on the deck have been identified for possible Rotor installations, an extensive design exploration was conducted, including almost 100 configurations with various numbers and positions of installed Rotors being investigated. For each configuration, different wind scenarios need to be examined, resulting in more than 100 simulations per configuration. Summarising the simulation results, the two best-performing configurations with two, four, and six installed Rotors are compared to each other in terms of total thrusts and energy savings, as shown in Figure 2, with their positions illustrated in Figure 3. The more rotors are installed, the higher the overall power savings. However, the energy savings per rotor is the highest in the case of two Rotors installation, and this aspect is important when calculating the total benefits and the Return of Investment (ROI).

The developed Eulerian method can consider a comparatively large design space with a significantly reduced numerical effort and is, therefore, particularly suitable for the initial conceptual design phase. Further, the overall (i.e., aero- and hydrodynamic) performance prediction is being systematically investigated utilising HSVA's Performance Prediction Tool "Ecolibrium" for wind-assisted ships. "Ecolibrium" (introduced already in NewsWave 2-21) is a modular-based, integrated, fast, and easy tool that considers the 6 DoFs of ship motion and all relevant aero-/hydro-forces to find the final equilibrium state and the minimal required propulsion power. Future work in FlettnerFLEET, including further development of "Ecolibrium" and experimental validation, etc., will be reported later in the coming issue of NewsWave.

contact: xing-kaeding@hsva.de

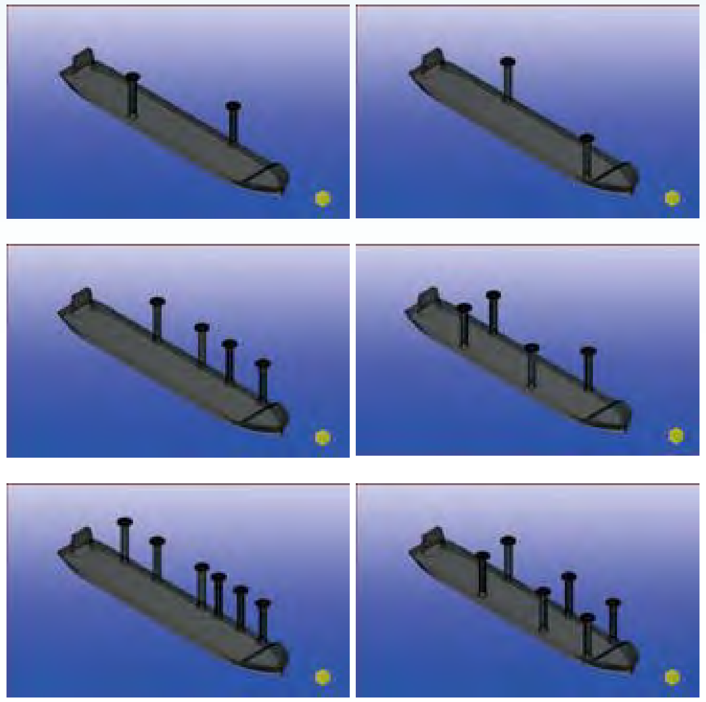
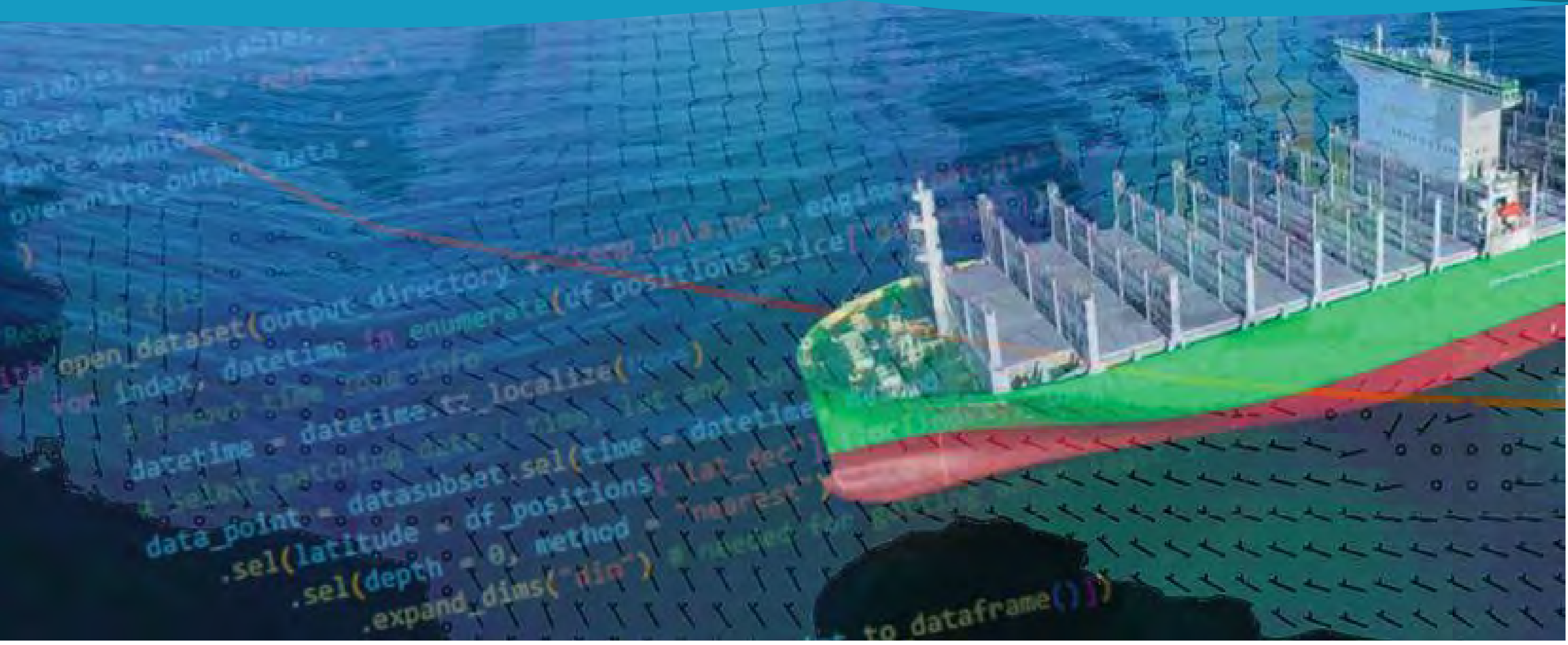
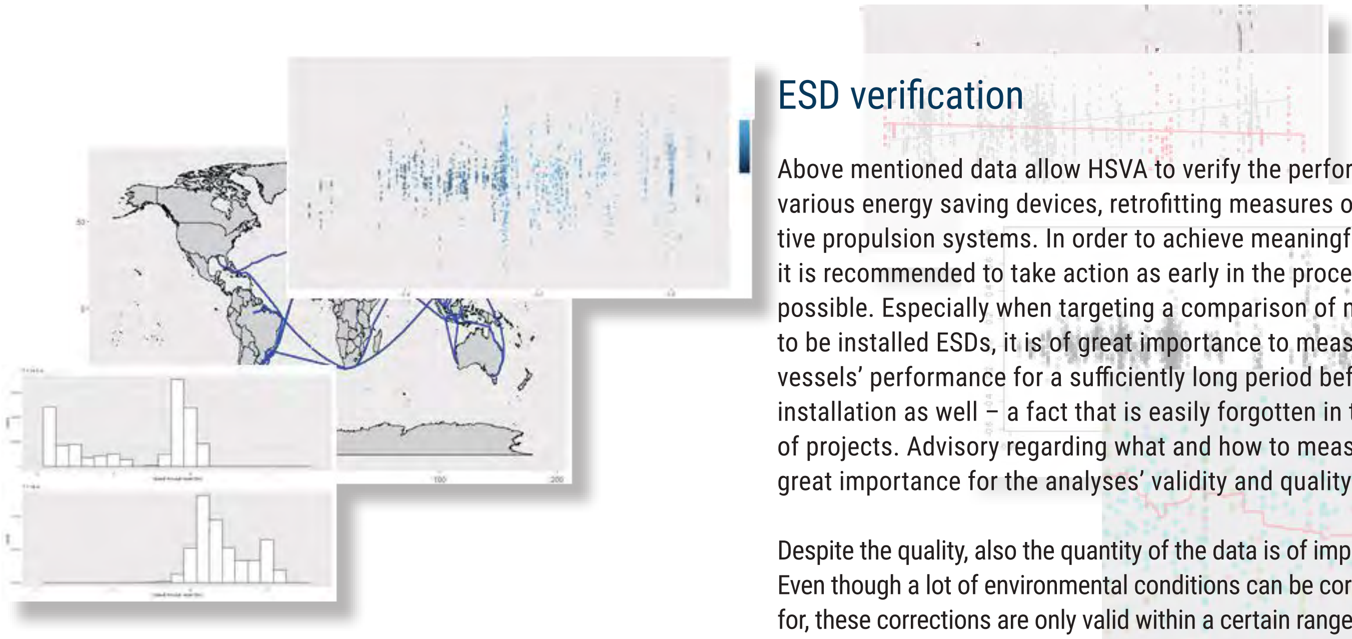


Figure 3: Examples of investigated best (left) and the second best (right) Rotor Configurations: two Rotors installation (top), four Rotors installation (middle) and six Rotors installation (bottom).

This project is funded by the German Federal Ministry for Economic Affairs and Climate Action.

Federal Ministry for Economic Affairs and Climate Action





Full-scale Performance Verification

Turning graveyard data into a treasure vault

Nowadays, it becomes more and more common to permanently log board data with the intention of using it, for example, for assessing and optimising the fuel consumption. Simply plotting the recorded information, such as power demand in function of ship speed, results in point clouds often with a clear trend but also with a significant scatter. In most cases, the deviations are large enough to swallow the impact of the effects of interest, making it necessary to filter, group and correct the raw recordings prior to analysis. If approached properly, valuable information can be extracted from these sets, allowing conclusions on favourable operating conditions, determining trends in fouling and thus identifying ideal docking periods or even verifying the gains of energy saving devices (ESD's), hull modifications, including application of anti-fouling paints, and propeller re-designs.

by Jan Richter and Jonas Wagner

The ideal data set

In order to properly work with on-board data, high frequency information in a good quality are needed. The recording frequency should be as high as possible (preferably one or more recordings per minute) to ensure a representable condition for each datum. This allows for identifying stationary periods which are most suitable for analyses.

At least the ship's position and heading, its speed over ground, the power demand, propeller revolutions, rudder angle, draught, water depth and apparent wind should be part of the data set. Including information about waves, water temperature, water density, air pressure, fuel consumption, hotel load, PTI/PTO and side thrusters will notably improve the analysis. Clear references (e.g. how 0° is defined for the wind or wave angles) and units of the data and the data source (measured, manually entered) should be included as meta-information to prevent confusions in interpretation.

ESD verification

Above mentioned data allow HSVA to verify the performance of various energy saving devices, retrofitting measures or alternative propulsion systems. In order to achieve meaningful results, it is recommended to take action as early in the process as possible. Especially when targeting a comparison of newly or to be installed ESDs, it is of great importance to measure the vessels' performance for a sufficiently long period before their installation as well – a fact that is easily forgotten in these kind of projects. Advisory regarding what and how to measure is of great importance for the analyses' validity and quality.

Despite the quality, also the quantity of the data is of importance. Even though a lot of environmental conditions can be corrected for, these corrections are only valid within a certain range. As an example, the added resistance due to wind can be corrected below a threshold value of Bft. 6, any observations above this value need to be filtered out. Additionally, sensor data is often affected by inaccuracies, be it general noise, temporary disturbances (e.g. dirt on a pressure sensor) or even complete failure. As a result, only approximately 20% of the initial data remain after filtering for valid and stable environmental and ship conditions. Hence, at least three month of continuous data are needed to perform detailed analyses.

Analyses going beyond ISO 19030:2025

The ISO 19030 standard dated 2025 strongly relies on filtering and only corrects for differences in displacement volume (within 5%) and wind. Furthermore, it averages data into 10 minute blocks, which in HSVA's experience may be too large for certain applications, such as performance gains identification. It is highly recommended to reduce the grouping into smaller time-blocks, if any. As long as reliable data are present, additional corrections may be used instead of filtering. Especially the effect of water density and salinity, moderate waves and shallow water can be included using established methods. More sophisticated procedures describing the aforementioned factors as well as additional effects, such as larger sea states, drift or (stationary) rudder positions deviating from the neutral rudder angle, ▶

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could be added if corresponding model test or simulation results are available, further increasing the valid data range. If speed-power relationships have been established through model tests on different draughts and / or trim conditions and have been validated / corrected by speed trials, the filtered and corrected performance can be related to these base cases, further increasing the confidence in the results. In addition to the corrections mentioned above that address instant / immediate effects on the vessel performance, also long-term effects need to be taken care of. Given enough data is available, performance corrections regarding fouling or other effects that develop over larger timespans can be dealt with.

Once all corrections and filters have been applied, the actual analysis can be performed. Usually, focus is put on a set of operating conditions (most relevant speed / draught combinations) instead of the whole speed / power curve. This is on the one hand due to lacking data and on the other hand caused by the fact that some variables such as speed and draught feature high uncertainties resulting from the way they are measured. Reasonably clustering the data is one way of coping with these uncertainties.

Benefitting from the vast range of analysis capabilities at HSVA

Thanks to these tools and procedures, HSVA is capable of getting the most meaningful results possible from your data, describing performance gains, resistance improvements or even fuel consumption reduction, Our services not only allow for verifying the performance of energy efficiency measures – ranging from propulsion improvement devices over propeller / rudder optimisation and hull cleaning / painting to retrofitting measures – but also for analysing and possibly even optimising air lubrication and wind assisted propulsion systems, such as Flettner rotors.

contact: richter@hsva.de / wagner@hsva.de

Driving the Development of International Standards

HSVA has been elected to be part of the ITTC Full Scale Ship Performance Committee that constantly improves and develops international standards regarding collecting, processing and evaluating full scale ship performance data.

IMO Manoeuvring Attestation

SOLAS Regulation II-1/28 requires providing the general ship particulars and main manoeuvring characteristics on board, easily accessible and available to navigators. IMO Assembly Resolution A.601(15) may be used for achieving this requirement.

by Jan Richter and Manasès Tello Ruiz

As sea trials are typically carried out on ballast draught, in deep and calm water and only for a limited number of manoeuvres, extrapolation to full load draught and the estimation of manoeuvres, which have not been physically conducted, should be realised through model tests and simulations. The findings of full-scale trials are used directly in the documentation, as well as for validating and calibrating the simulation results.

The recommended format of the manoeuvring information according to IMO Assembly Resolution A.601(15) is threefold: a manoeuvring booklet, a wheelhouse poster and a pilot card.

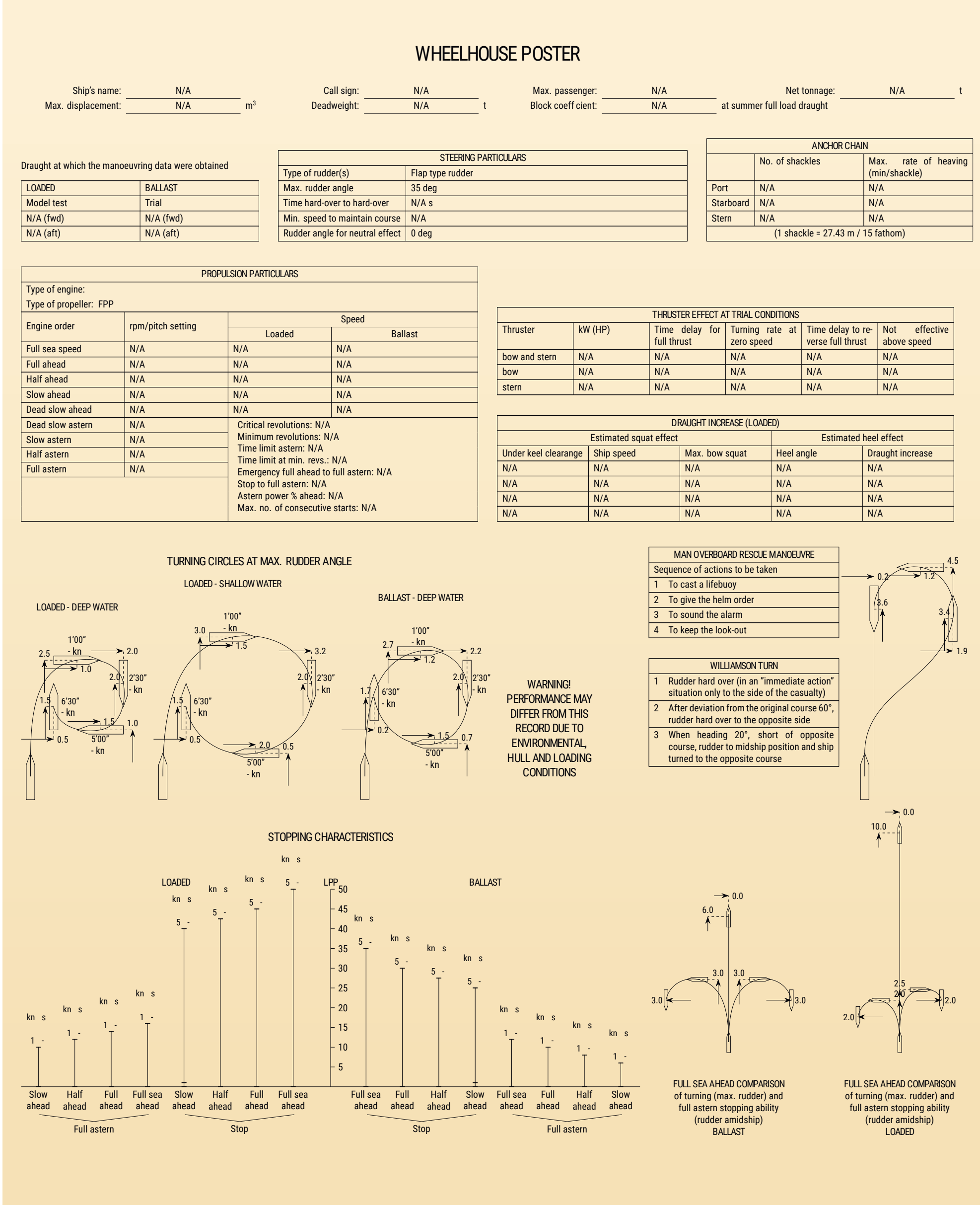


Figure 1: Wheelhouse poster template

The permanent information available on the pilot card and on the wheelhouse poster are part of the most comprehensive document, the manoeuvring booklet. The booklet contains the general description of the ship particulars as well as relevant information on engine, rudder, lateral thruster and anchor. Furthermore, the main engine, manoeuvring and stopping characteristics for deep and for shallow water as well as the effect of wind on the course-keeping and manoeuvring characteristics at low speed are part of the booklet.

The wheelhouse poster (Figure 1) should be permanently displayed in the wheelhouse of the ship, providing information on the general particulars and describing the manoeuvrability, mostly in form of diagrams and tables.

Finally, the pilot card, which needs to be filled in by the master with the current loading condition and manoeuvring equipment, should be provided to the pilot at the time of boarding the ship.

The base information for these documents are obtained from sea trials. According to IMO the absolute minimum trial scope should include:

- Two stopping tests, from full sea speed ahead as well as from full ahead speed to full astern.
- Man-overboard manoeuvre.
- Characteristics of main engine, including speed trial information.

The remaining scope may be recorded during sea trials or based on model tests and simulations. Due to restricted environment and loading conditions, it is unlikely to cover the complete information that is required for the documentation during sea trials but HSVA highly recommends to perform as many manoeuvres as possible on the actual ship. As a minimum manoeuvring test program, the course keeping and yaw checking abilities, rudder characteristics, turning circle ability, man-overboard-manoeuvre, lateral thruster capabilities at zero speed, the stopping and the acceleration performances are recommended.

These additional sea trials only require a few hours of additional time and greatly assist in verifying the model test results and improving the simulations of the remaining manoeuvres.

HSVA services encompass the preparation of manoeuvring booklet, wheelhouse poster and/or pilot card. With our model test facilities, numerical tools and tools developed specifically for full-scale speed and manoeuvring trials we assist in gathering all information required to fulfil the SOLAS Regulation II-1/28.

contact: richter@hsva.de / truiz@hsva.de

Underwater Radiated Noise Footprint

The underwater radiated noise (URN) from ships influences and in worst case harms marine life. For this URN, the cavitating propeller is often the dominant source over a wide frequency range. To keep the impact on marine life at a justifiable level and prevent irrevocable damage from marine life, different approaches for lowering the URN are currently discussed and partly already implemented.

by Björn Carstensen, Herbert Bretschneider and Lars Koopmann

The International Maritime Organization (IMO) facilitates a voluntary approach[1]. The outcome of this approach is evaluated after an experience building phase in 2026. A key aspect of the guideline is the URN management plan. The implementation of this plan for a vessel includes three steps: determine the ship specific baseline, define reduction targets and finally choose operational measures. The guideline emphasises that the topic of URN should be included early in the ship design or retrofit process and be evaluated with the close connection to the energy efficiency. As a prediction from model tests is legitimate to determine the baseline, strategies and measures for the reduction of URN can be investigated cost efficient already during the stage of model testing. The implementation of a URN management plan is of interest for shipowners and operators as the guideline suggest introducing incentives for vessels with low URN or for vessels following a URN management plan (e.g. discount on the port dues or fairway fees).

Another approach, which is addressed by the IMO but also the European Union (EU) is the definition of protected areas with regional, stricter requirements. The IMO for example disseminates a guideline for Inuit Nunaat and the arctic[2]. Moreover, they suggest using the approach of restricted or protected areas also for further regions in their general URN guidelines[1]. The EU follows this by introducing an additional regulation for certain regions. For continuous noise, the protected areas and their limits are linked to the habitat of the respective species[3]. In the habitat 20% of the area should not exceed noise levels above “Level of Onset of Biologically adverse Effects” (LOBE) in any month of the assessment year. The regulation on EU level therefore does not set out direct limits to individual noise sources but sets out more general limitations to avoid significant damage to a target species in its habitat. How this limit is fulfilled needs to be implemented in national laws. How the limits can be specified and how the EU regulation can be brought to national law is currently discussed for the North-East Atlantic by OSPAR[4] and for the Baltic Sea by HELCOM[5]. But as the limits depend on the species living in certain regions and as the national laws may also vary between different nations, vessels sailing through different areas may face various regulations.

Yet another development exists on side of the classifications societies, who developed individual, voluntary class URN notations (e.g. see DNV Silent Class Notation[6]). The class notations provide an orientation of limit curves, trials and the certification process of URN of a vessel. But as the requirements to obtain a URN class notation differs between the different societies, a comparison of various vessels is difficult. Also, connecting incentives or punishments for vessels to a class notation is challenging as long as the notations differ between the societies.

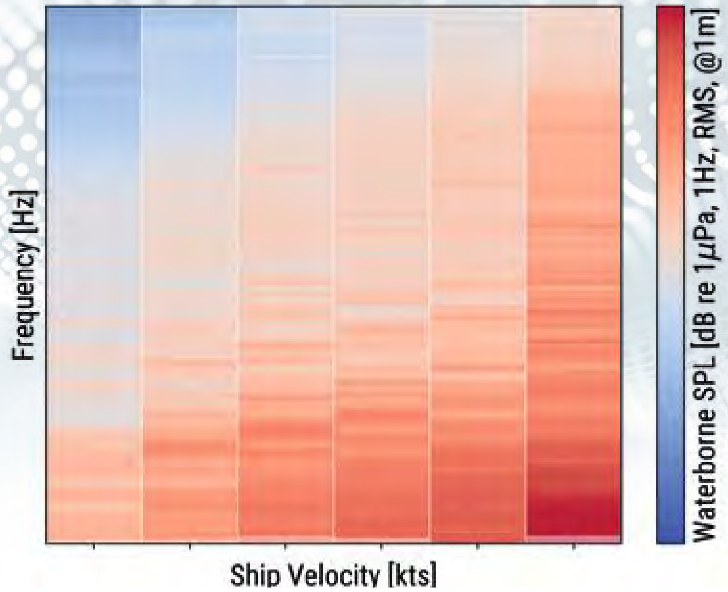


Figure 1: Exemplary URN full scale prediction from model test measurement for the operating speed curve.

With an ongoing increase in URN emissions[7], the need for protection of marine life is evident. The regulatory side for limitation of URN is under rapid development and regulations might in future differ regionally. Therefore, the check for conformity with limits at single operating points during building stage of a vessel is not meaningful. An investigation of the URN level of propellers for the operating speed curve becomes handy for this purpose. Furthermore, the comparison of different propeller designs regarding their URN level is more relevant, when the whole speed range is investigated. For competing propeller designs, the URN level might differ strongly even with comparable efficiency. Moreover, some propeller designs react very sensitive regarding the speed, while others maintain a certain radiated noise level over a wide speed range. Therefore, the behavior of the propeller over the speed range determines if and how certain limits can be fulfilled.

In Figure 1, an exemplary URN full scale prediction from model test measurements for the operating speed curve is presented. The x-axis shows the ship speed, the y-axis the frequency range and the colour depicts the sound pressure level (SPL). On the left, at low speeds, the SPL of the vessel is on a low level. With increasing speed, the SPL increases as well. But when closely observing the development over speed, the SPL even decreases for certain frequency bands before increasing again. Also, a significant increase in SPL is observed between the last two speeds. Here, a minor decrease of the ship speed would already lead to a significant reduction in SPL. While in the mid-speed range the effect of the ship speed is less pronounced.

As can be seen from this example, the investigation of propeller URN along the operating speed curve of a vessel holds much more information than at an arbitrary single operating point. Also when comparing different propeller designs or appendages, the comparison is much more meaningful. The investigation of URN along the operating speed curve, as shown in Figure 1, can be easily added to standard cavitation tests (e.g. cavitation observation or pressure pulse measurements) with only little extra effort. The cavitation team of HSVA would be happy to adopt this approach to your next project and to assist you in investigating and finding measures to lower the URN.

contact: carstensen@hsva.de / bretschneider@hsva.de / koopmann@hsva.de

1 IMO, 2023, MEPC.1/Circ.906: Revised Guidelines for The Reduction Of Underwater Radiated Noise From Shipping to Address Adverse Impacts on Marine Life.
2 IMO, 2023, MEPC.1/Circ.907: Guidelines for Underwater Radiated Noise Reduction in Inuit Nunaat and the Arctic
3 EU, 2024, Communication from the Commission – Commission Notice on the threshold values set under the Marine Strategy Framework Directive 2008/56/EC and Commission Decision (EU) 2017/848
4 https://www.ospar.org/work-areas/eiha/noise
5 https://helcom.fi/action-areas/marine-litter-and-noise/underwater-noise/
6 DNV-RU-SHIP Pt.6 Ch.7 Sec.6, Jul. 2024
7 Jalkanen, Johansson et al., Underwater noise emissions from ships during 2014–2020, Environmental Pollution, Volume 311, 2022, https://doi.org/10.1016/j.envpol.2022.119766.

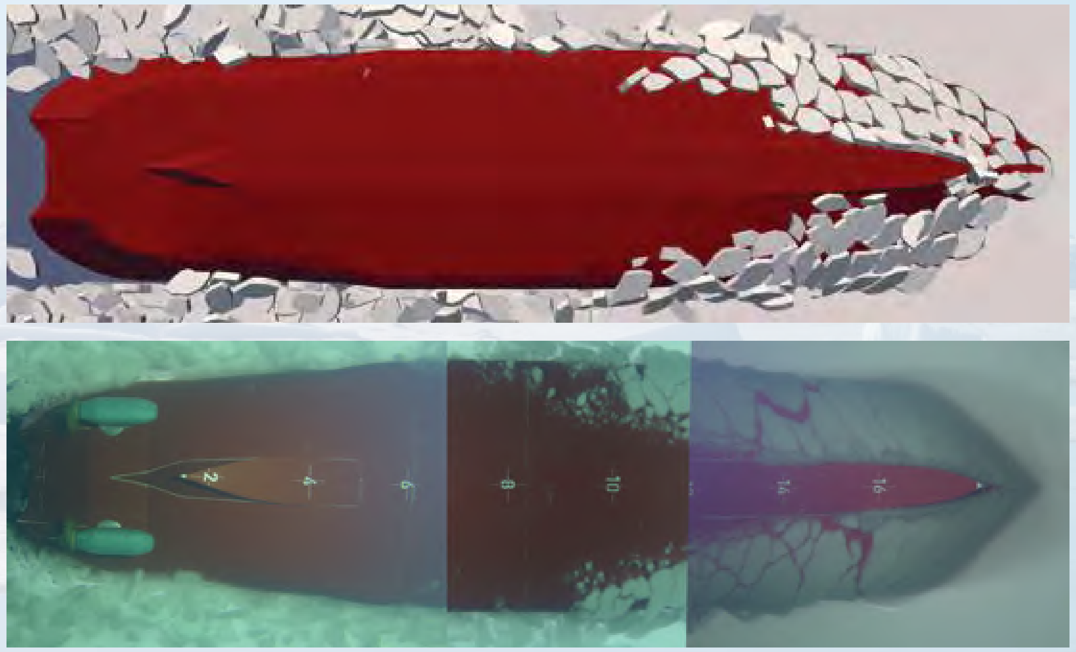


Figure 1: Calibration based on existing model test underwater video footage

Simulating Ship-Ice Interactions to Optimise the Hull Shape

Besides the ice breaking resistance, the ice clearing performance of a hull shape is one of the most critical aspects to consider when designing an icebreaking vessel.

by Quentin Hisette

The ice clearing performance can be defined as the ability of the bow to transport ice pieces away from the hull after breaking solid ice. This is particularly important because ice pieces that reach the flat hull bottom will first induce added frictional resistance on the hull and eventually interact with the thrusters and propellers. The propellers will then consume a significant part of the engine power to mill ice rather than to generate forward thrust.

Methods to achieve an efficient ice clearing usually involve well defined bow lines, a sufficient deadrise angle and a clearing fore foot/skeg. Those geometrical aspects are usually adjusted according to the designer's experience.

Besides their experience and data based approach, HSVA's designers are now frequently including numerical ice clearing simulations in the process. The simulations are performed using SIBIS, a software package developed by Multiconsult, D-ICE Engineering, DNV and Equinor. SIBIS stands for "Simulation of Interaction between Broken Ice and Structures", although its current version has been expanded to multiple kinds of ice features (including level ice, ice ridges and brash ice). SIBIS is a time-domain simulator based on a multibody solver for contact detection and force calculation. The software has been calibrated thanks to contributions from multiple partners, including HSVA. Its main capabilities include:

- Semi-realistic simulations of the interaction of sea ice with ships and offshore structures,
- Time domain simulations of mooring and structural response,
- Simulation of ice breaking, including crushing, bending, splitting and buckling failure,
- Simulation of the rubble transport and accumulation on ship hulls.

The typical process of an ice clearing simulation starts by simulating an existing design, for which model test underwater video footage is available. Various parameters are used to calibrate the simulations in order to obtain results as close as possible to the model test observations (Figure 1). Then the same parameters are used to simulate the new, untested design and evaluate its ice clearing ability (Figure 2). The amount of ice reaching the hull flat bottom and the propeller area, as well as the remaining ice in the channel behind the vessel are three criteria used to evaluate the clearing performance.

In a similar manner, SIBIS can also be used for parametric studies during the hull lines optimisation phase. Small modifications of the hull lines, for example the fore foot size or the fore shoulder geometry, can easily be modelled, meshed, simulated and compared to the original design several times per day.

Another common application of SIBIS is the calculation of loads on offshore or ship-shaped structures, for example during station keeping (Figure 3).

contact: hisette@hsva.de

Figure 2: Ice clearing simulation

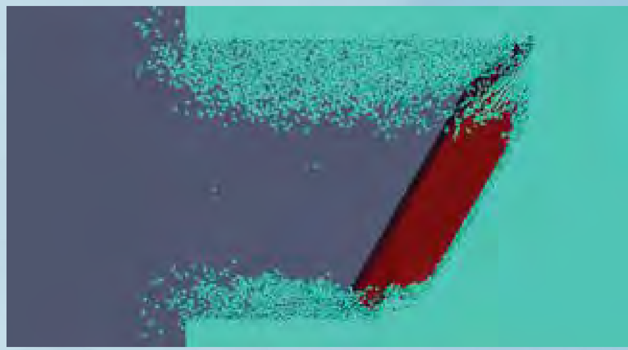


Figure 3: Station keeping in thin ice

New Research Project SMiLLA

Research on ships and structures in ice covered waters has always been a core competence of HSVA. This presupposes research and continuous improvement of processes to get the best quality ice model tests.

by Till Zorn

We are happy to announce the start of the new joint research project SMiLLA (Sommer-Modelleis für universeLle LaborAnwendungen, engl.: summer model ice for universal laboratory applications) together with the University of Hamburg (UHH) and the Hamburg University of Technology. The project is funded by German Federal Ministry of Education and Research, started in December 2024 and has a duration of 1.5 years.

The goal of the project is to develop a new kind of model ice. The current practise and procedures in ice model testing typically reflect winter ice conditions only. Due to climate change and the rise of ship operations in summerly ice-covered waters, there is potential for improvements on resources, emissions and fuel consumption of ships in these conditions. Therefore, the new type of model ice is planned to be softer and less brittle than winter model ice. This requires the development of new ice preparation methods to accommodate the correct mechanical properties and scaling laws.

Partner at UHH is the Institut für Meereskunde (engl. Institute of Oceanography). There, a small research ice basin exists and is utilised to enable series of tests on model ice itself. In close cooperation, the project partners develop model ice that features properties and behavior of summer sea ice. In the end, the new model ice will be used at HSVA and UHH. HSVA will expand its portfolio of ice model testing and UHH will benefit from research possibilities e.g. on melt ponds in summer sea ice conditions.

contact: zorn@hsva.de

Summer sea ice with melting ponds (copyright by Niels Fuchs)

Lina Borggräfe

Lina Borggräfe has joined HSVA in May 2024. After completing an apprenticeship as a boatbuilder at a shipyard that is specialising in classic wooden yachts, she gained hands-on experience in the construction of boats. Afterwards, she deepened her knowledge while finishing a degree in Yacht Design and Production at Southampton Solent University. During this program she acquired both theoretical and practical insights, broadening her perspective on shipbuilding and the yacht industry.

Before joining the HSVA she worked for a superyacht company in the outfitting department and 3d modeled various ships.

She now works as CAD Coordinator in the production department. With her background she is working closely with the workshops as well as the project managers to ensure that the models are built to our quality standards, while trying to find ways for optimising the workflow and its outcome.

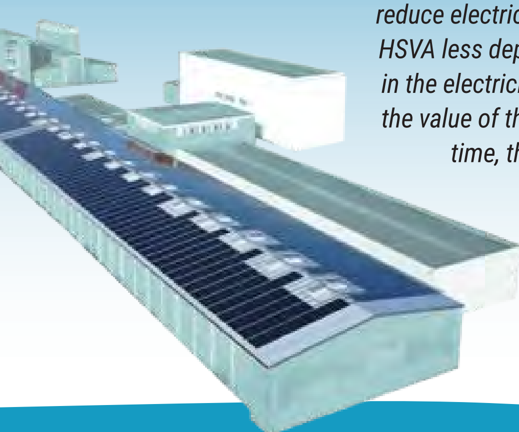
Growing up on an island she learned how to sail at an early age. In her free time she tries to spend as much time on the water as possible sailing with family and friends on both North and Baltic Seas.

HSVA celebrates the start of a more sustainable future

On February 14, 2025, we invited all HSVA employees to a gathering in the cavitation building to celebrate the official commissioning of Hamburg's second largest photovoltaic system.

by Axel Schult

This significant step not only marks the start of a more efficient use of resources, but also further progress towards energy-efficient refurbishment. We were delighted to welcome Mr. Jens Kerstan, Senator for the Environment, Climate, Energy and Agriculture of the City of Hamburg, to the celebrations as our guest of honour. In his speech, Mr. Kerstan praised the project with the following words: *"The new HSVA photovoltaic system is a real milestone with its position as the second largest system in Hamburg. It not only helps to reduce electricity costs, but also makes HSVA less dependent on fluctuations in the electricity market and increases the value of the property. At the same time, this project makes a significant contribution to environmental protection and the energy transition. It also highlights the important role of our environmental partners from Hamburg's business community and the great interest of the private sector in the energy transition."*



Forecasted yields and future prospects

With the commissioning of the new photovoltaic system, we are making a significant contribution to a more sustainable energy supply. As outlined in the last issue, we have set ourselves the goal of becoming CO_2-neutral by 2030. The system is expected to save around 269.756 kg of CO_2 per year. With a total output of 999.4 kWp and a predicted annual yield of around 822.6 MWh, the system will make a significant contribution to reducing energy consumption. With a self-consumption rate of around 78.8 %, external energy requirements will be significantly reduced. The current self-sufficiency rate of 30.4% could be increased in future by implementing an electricity storage system. The expected payback period for the photovoltaic system is around nine years, based on the savings from the reduced external power consumption and the increased energy efficiency.

Inauguration celebration © BUKEA