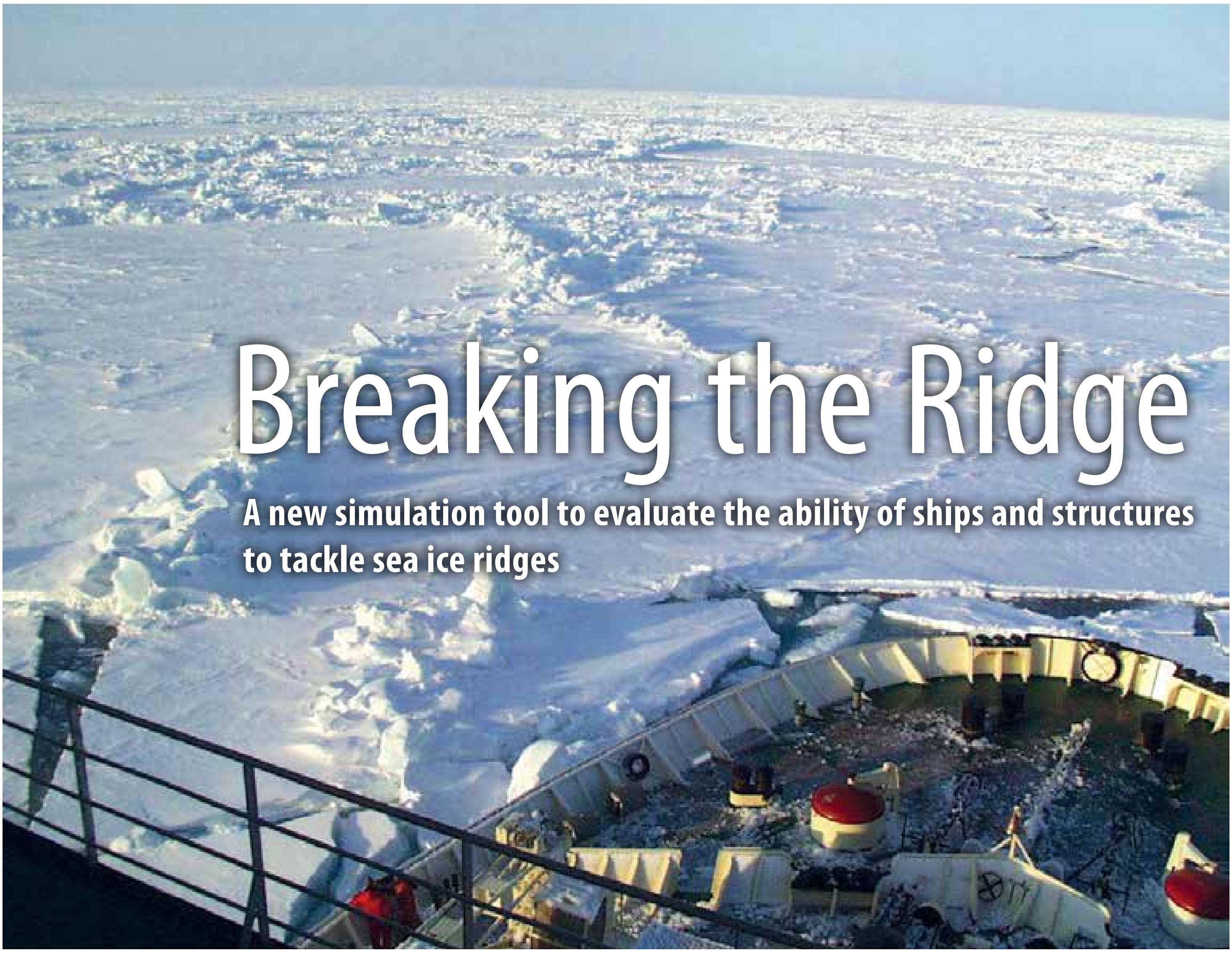
issue 1-17

HSVA

newswave

The Hamburg Ship Model Basin Newsletter



Breaking the Ridge

A new simulation tool to evaluate the ability of ships and structures to tackle sea ice ridges

HYKAT – testing energy-saving hub caps with fins

NEUWERK – wind tunnel tests for German multi-purpose vessel

AERONAUT – better air flow for less fuel consumption

editorial

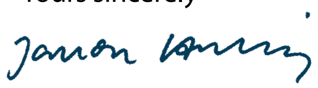
Dear reader,

"We are sailing in heavy seas." This is being expressed in the same or a similar way in many contexts these days. Our previous NewsWave was issued shortly before the trade fair SMM 2016. At the fair we spoke many of you and discussed how we all deal with the world wide situation and it was good to realize that there were a lot of creative and innovative ideas around. Also by the large number of exhibitors and visitors from all over the world we could find an atmosphere of looking for opportunities and reflecting strengths and weakness rather than despair.

HSVA is currently enforcing its strategy being built upon three major services – model testing, calculations and full scale measurements in the fields of hydrodynamics and arctic technology, all three accompanied by thorough advisory services. We realized that the demand for our services in CFD and theoretical analyses as well as hull line optimization is growing despite the situation in the shipbuilding market. And we are deepening our insights in many adjacent areas like wave-ice interaction. This is being shown in the current issue of NewsWave. We are excited about our new developments in numerical calculations, as different as a discrete element method for the simulation of breaking ice ridges as well as advanced tools for designing the ship of the future.

In particular in hard times it is of vivid importance to further develop, to identify our opportunities and to discover the potential in change, together with our large network of partners and clients. This is what we enjoy at HSVA and we are proud to present some of our recent spectacular results on the following pages!

Yours sincerely



Dr. Janou Hennig

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Discrete Element Simulation of Ships and Structures Breaking through Ice Ridges

Sea ice ridges are one of the most difficult obstacles encountered in ice-covered seas. HSVA is currently developing a new simulation tool to evaluate the ability of ships and structures to break through these ice features.

by Quentin Hisette

When two ice sheets come into contact, they break and small pieces of ice accumulate along a line, creating large floating structures embedded in the ice sheet. With a keel depth sometimes exceeding 30 m, ice ridges represent considerable obstacles to ship navigation, but also to floating structures and vessels under dynamic positioning operations.

Numerical modeling of ice ridge creation, ice ridge breaking and ice ridge/structure interaction are relatively new research topics. Naval architects and ship designers at early design stage are often interested in assessing the capability of a vessel to navigate through ice ridges or in evaluating the capability of a floating platform under DP-assisted mooring to hold position against a drifting ice ridge.

A new simulation tool based on the Discrete Element Method (DEM) has been developed to address this demand from the industry. The main idea of developing the DEM software is to create a numerical model for interaction between ice pieces, and later to simulate interaction of these ice pieces with ship hulls or structures.

The Discrete Element Method is used for computing the motion and mutual interaction of a large number of particles. It finds application in such industries like mineral processing, powder metallurgy, rock mechanics, etc. The equations of translational and rotational motions of elements are solved numerically, taking into account multiple internal and external forces.

In this project the capabilities of DEM are used to simulate the ice ridge as a large set of discrete ice blocks interacting with each other. The simulation runs on the basis of a powerful algorithm for contact detection and calculation, able to sort out efficiently all potential contacts and characterize for each of them the overlap polyhedron (geometry, volume, center of volume and contact area).

This is computationally different, more complex and more CPU consuming than methods using only the penetration depth to compute the contact force but ►

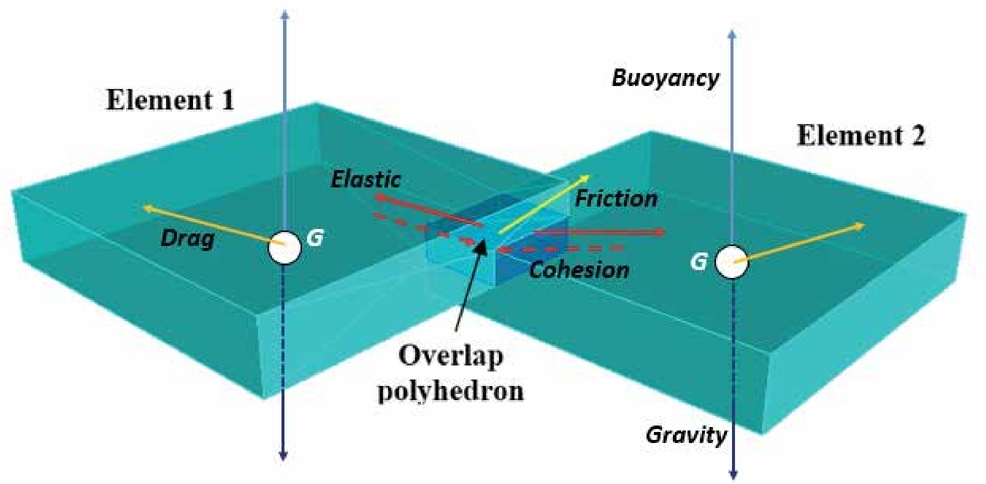


Figure 1: Interaction forces between elements

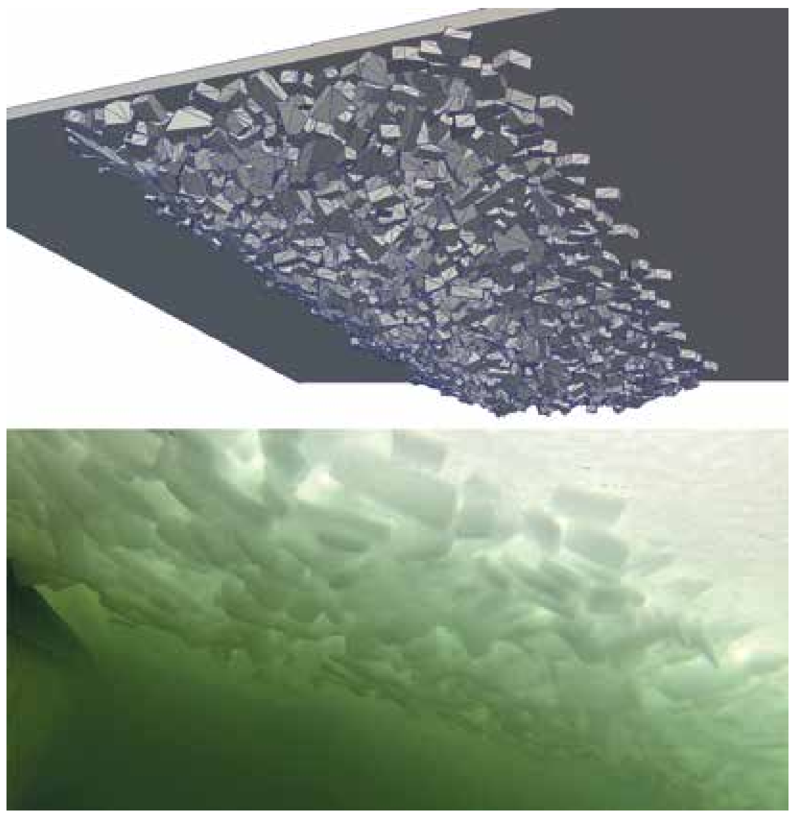
has the advantage to generate smooth changes in overlap volumes and contact forces, allowing formation of stable heaps of elements and providing excellent numerical stability.

Gravitational, buoyancy, hydrodynamic and contact forces are calculated for each element of the ridge keel (Figure 1). In particular, contact forces are calculated as the sum of a repulsive, a dissipative and a cohesive force, including a tangential friction force.

The equations of motion are solved at each time step and for each element in order to determine its position and orientation. For this purpose a Gear's predictor-corrector algorithm is employed, providing stability and efficiency, as it requires neither a matrix inversion nor the solution of a non-linear system of equations.

Ice rubble dimension and shape are modeled according to experimental distributions measured in HSVA model ice ridges. After initialization along a 3-D standard grid, the elements are compacted in order to create an ice ridge of the required profile and porosity. The resulting numerical model is in good correspondence with observations (Figure 2).

Only the ridge keel is simulated by discrete elements while the consolidated layer is represented as a fixed plane over the waterline, as it contributes to significantly less of the total resistance than the rubble ice keel. When simulating the interaction with a structure, an added ice resistance is introduced to consider the effects of level ice breaking.



Ship hulls and offshore platforms geometries are then loaded in the simulation. The hull surface can be created and meshed with any CAD system supporting the conventional .OBJ file format. Non-convex geometries are modeled as composite of convex sub-meshes rigidly connected between each other.

During data import the program reads the .OBJ file, calculates the number of vertices and faces, computes topological information from these input data, computes entries of face equations and stores information into the DEM data structures. The structure is then given a predefined velocity, force or propeller revolution according to the simulation type. For floating geometries, buoyancy is pre-calculated for various combinations of drafts, pitch and roll angle. The actual "in-time" values are then interpolated between these pre-calculated values for the actual hull position and orientation.

Figure 2: Comparison of ridge numerical model (top) with model ice ridge from HSVA ice tank (bottom)

Simulation exhibits very satisfactory results in comparison to ice model tests (Figure 3 and 4). At impact with the ridge, the ship velocity drops rapidly while ice pieces are mainly displaced downwards. Velocity starts increasing again after the fore shoulder has passed the deepest point of the ridge keel. Relatively little ice is dragged under hull bottom as the parallel midbody moves through the broken ridge.

This simulation concept can easily be expanded further towards modeling ship navigation in various ice formations such as brash ice and broken ice fields. ■

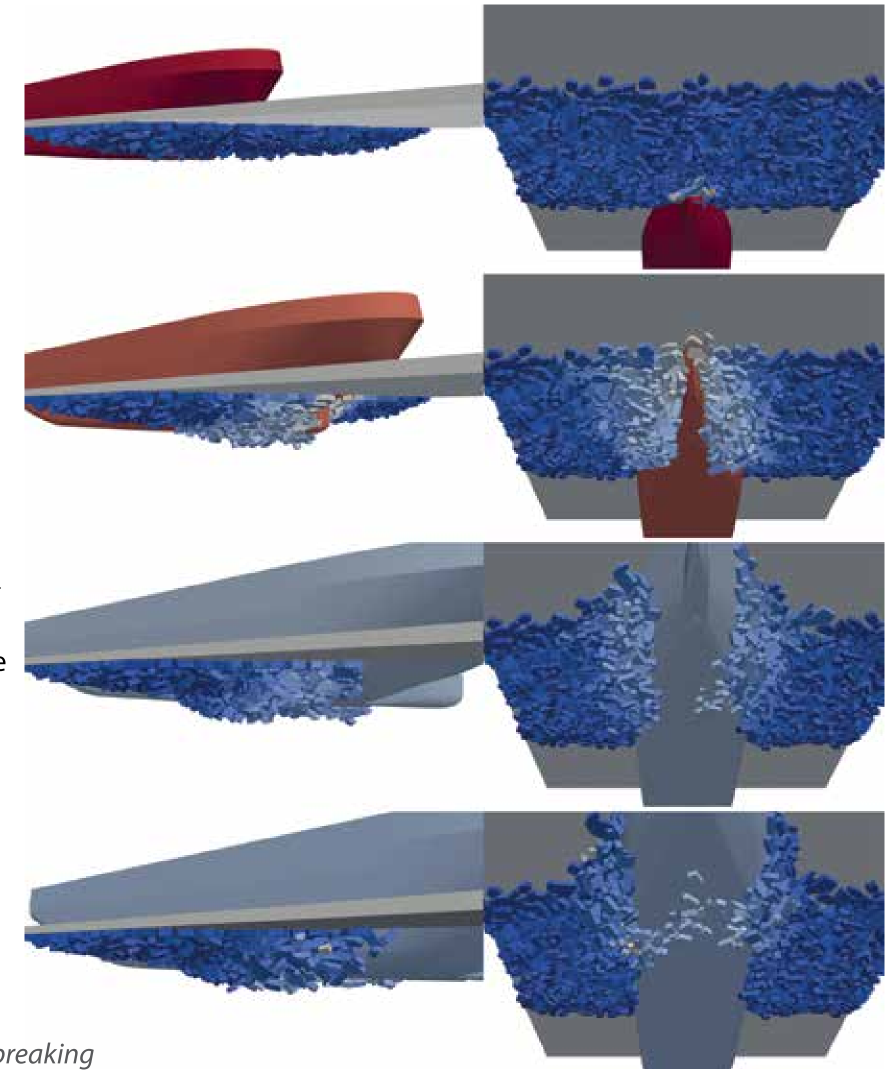
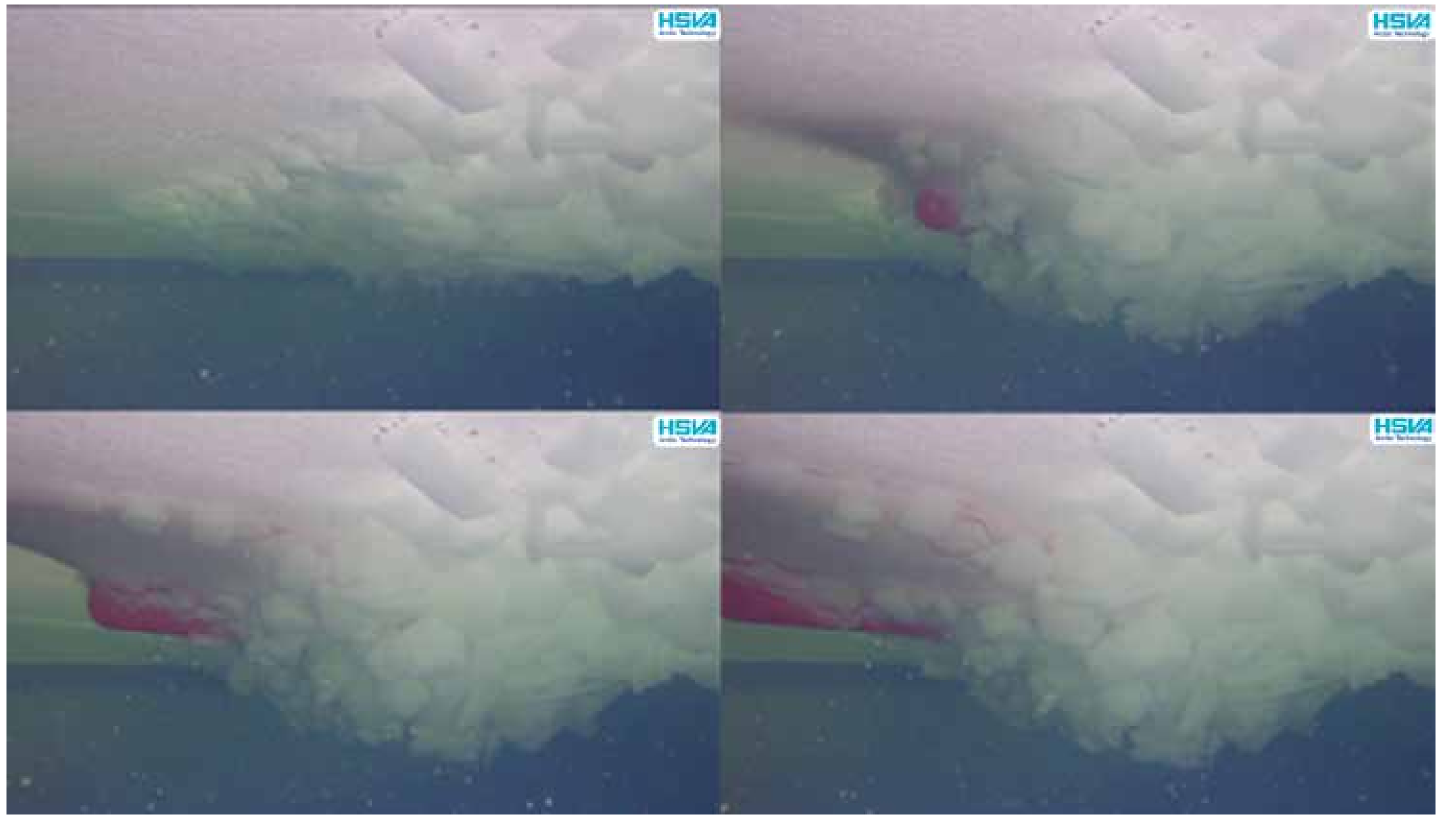


Figure 3: Visualization of the simulation results (ship and ice elements colour denotes their respective velocity, from zero for dark blue till 0.35 m/s for dark red)

Figure 4: Underwater video of model test ridge breaking



HSVA - Setting the Standard for Ship Design Optimisation

The new European Research project – HOLISHIP - *Holistic Optimisation of Ship Design and Operation for Life Cycle* sets out to substantially advance ship design to achieve much improved vessel concepts for the 21st century. This includes all relevant design aspects such as energy efficiency, safety, environmental compatibility, production and life-cycle cost to deliver the right vessel(s) for future transport tasks. HSVA leads this project which assembles 40 European partners from ship building, design, operation, maritime research, classification and academia to address this demanding task.

by Jochen Marzi

HOLISHIP will take ship design to a new approach that integrates market analysis and demand, economic, efficiency, safety and environmental footprint considerations and includes life-cycle cost aspects, hydrodynamic hull form design, structural design, optimal selection of prime movers and outfitting. Based on set mission requirements this "complete-holistic" approach enables the formulation of a rational foresight analysis for the viability of the product model over its life cycle ("from cradle to cradle"). It considers all fundamental steps of the traditional "ship – design spiral", which, however, are better illustrated today by a system approach, which is implemented in practice by a "shell / synthesis of integrated design s/w tools" as indicated in Fig. 1. A detailed elaboration of the project's objectives and of the followed approach is described on the project web site at **www.holiship.eu**.

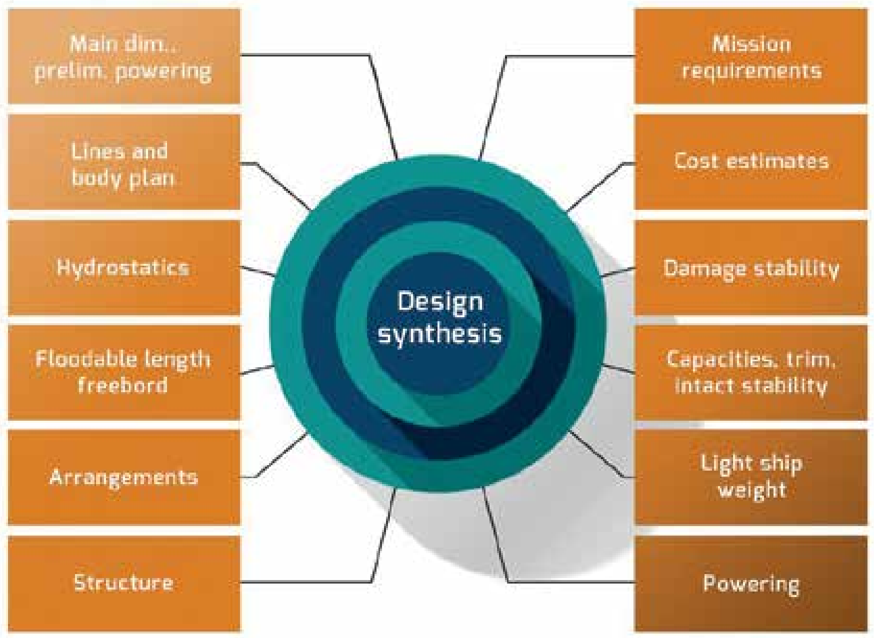


Figure 1: „HOLISHIP Integrated System Approach – Design Synthesis"

Coordinating this huge project means a new challenge for HSVA too. At first glance it might not be natural that a model basin acts as coordinator of a design development project. However, looking closer it becomes evident that a vast number of ship functions and hence design aspects are influenced by hydrodynamic – and inherent hydrostatic – characteristics. The relation of a ship to its surrounding medium determines major features of the later product and thus it appears not at all unreasonable that we as hydrodynamic experts have taken a leading role in this endeavour.

What does HOLISHIP mean for HSVA? Traditionally (re-)acting as a consultant of the maritime industry to determine the properties and quality of a given design, the model basin performs hydrodynamic analysis and experimental testing for its customers. Although the results of the analysis often lead to recommendations how to improve a given design and although optimisations of hullforms are a standard, the integration of the hydrodynamic work into the overall design process of a new vessel is still relatively weak. In the past this led to considerations that further room for improvement of the hydrodynamic properties of a new ship and hence its overall performance could be achieved when linking / integrating hydro-design more closely with the overall ship design functions. HOLISHIP's new design synthesis approach now offers the opportunity to do so. In its final evolution the concept, the platform developed in the project and our tools being integrated in the platform ▶

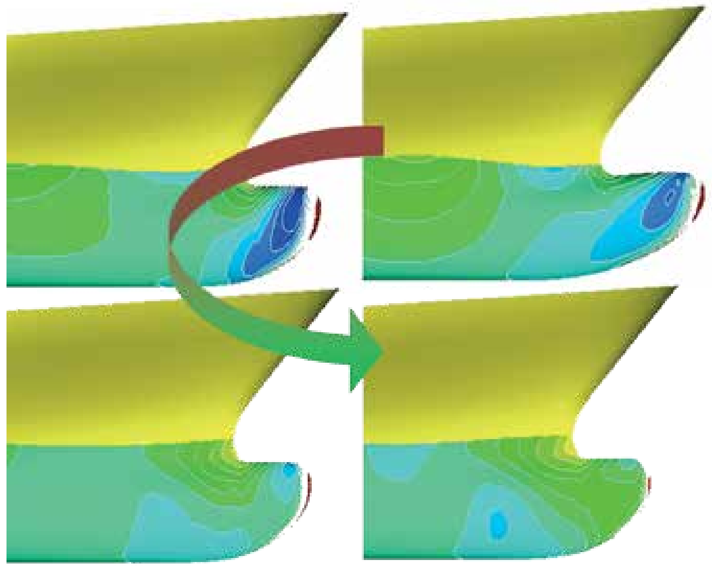


Figure 2: Hullform – bulbous bow optimisation for slow steaming

will provide the basis for better, more integrated customer relationships which in turn will help all players, HSVA as well as our customers to collaborate on more complete optimisation projects and thus yield better ships.

Together with the start of the HOLISHIP project in autumn 2016 Prof. Apostolos Papanikolaou, after his official retirement from the National Technical University of Athens (NTUA), has joined HSVA to accompany the developments in the project. Prof. Papanikolaou is a world renowned authority in the field of ship design and ship hydrodynamics. We discussed together the motivation for the project, the importance of integrated hydrodynamic design and his move to Hamburg.

HSVA: Prof. Papanikolaou, you are the spiritus rector behind the HOLISHIP concept. How did the idea for this project evolve and what will be the main advance compared to today's ship design practice that you anticipate?

The idea for this project started evolving in my mind maybe two decades ago, when we first managed to integrate a series of professional naval architectural (like NAPA) and in-house software tools into the "design software platform" of the Ship Design Laboratory of NTUA and successfully demonstrated the rationale of our approach in a series of case studies for various types of ships. All conducted case studies were industry driven, either in the frame of EU funded projects or bilateral Joint Industry Projects, thus it was ensured that the outcome was well monitored and critically assessed. Having worked on basic research in this area for prolonged time, it was straightforward to next formulate/develop in a *"bottom-up"* approach the HOLISHIP concept, the origin of which, when looking *"top down"* is believed to be in *Metamorphosis of Aristotle*, when *"holism"* was introduced as a new direction in philosophy, science, and much-much later in technology. In HOLISHIP terms, the holistic approach to ship design is nothing else than the multi-objective and multi-disciplinary optimisation of ship design for life cycle (Papanikolaou, Computer Aided Design, 2010). Assuming the successful implementation of the holistic approach into a (as) "complete" (as possible) design software platform, the main advances, compared to today's design practice, are anticipated to be: much shorted lead times for the design development, lower design costs, exploration of a huge design space with hundreds of alternative/feasible designs, compared to few point designs today, holistically optimised, superior designs considering in parallel all inherent interactions, between say hydrodynamic hull form and structural design, while this is nowadays considered sequentially in few point designs.

The expert's view - interview with Prof. Papanikolaou.

HSVA: Which role do hydrodynamics play in this context?

Hydrodynamics is for many ships (and especially for the high performance ships) the main discipline supporting ship design. I include to hydrodynamics trivially hydrostatics and stability, namely all phenomena related to ship's hull contact with water. Whereas building and outfitting a ship may be a complex, but straightforward task resembling the development of other steel structure products, it is hydrodynamics that needs specialised and often profound knowledge to be properly addressed by

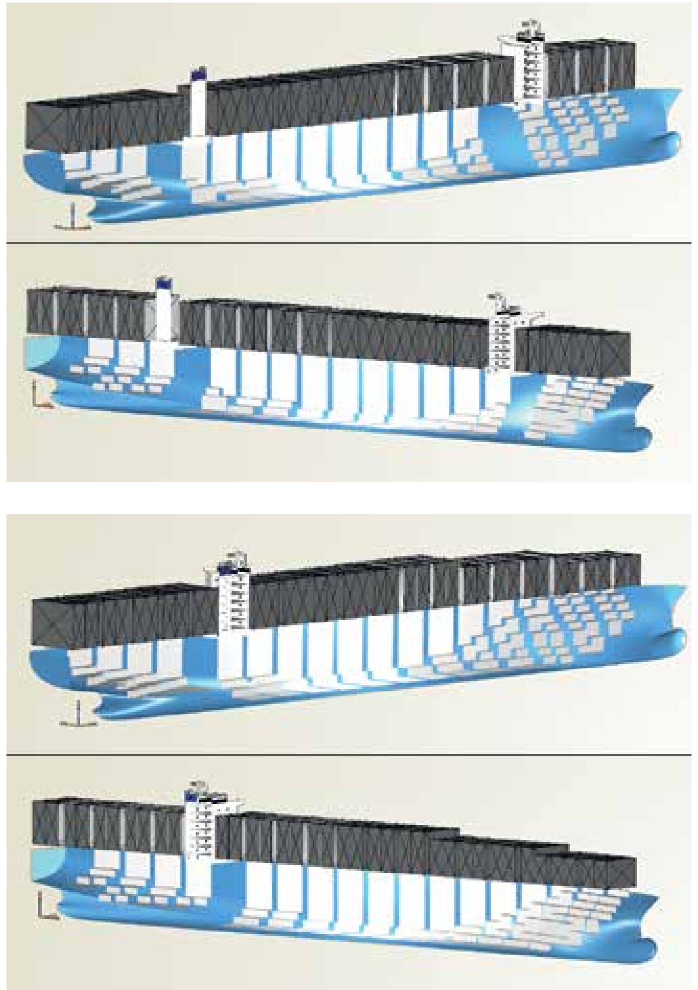


Figure 3: "parametric design and multi-objective optimisation of containerships"

(preferably) naval architects. Hydrodynamics is a classical subject of optimisation, when looking into ship's performance in calm water and in waves, comfort and safety. In recent years, we see, also, more and more aerodynamic studies and related optimisation studies of ship's superstructure taken place by advanced numerical methods. In the context of HOLISHIP it is not surprising that ship hydrodynamics (and aerodynamics) is playing a very significant role. It will allow the integration of a series of well-established hydrodynamic codes (CFD and panel codes) from various HOLISHIP partners (including HSVA's prime hydrodynamic software tools) for the determination of ship's performance in calm water and in waves. In practice, this means that a series of hydrodynamic software tools will be integrated on a common design software platform, allowing the hydrodynamic assessment of hundreds of parametrically generated hull forms and the rational identification of the best design variants with respect to set criteria.

HSVA: Why do you think that a ship model basin such as HSVA is the right place to be when coordinating a project like HOLISHIP?

Allow me first a personal note: Even though I did research and was teaching for over three decades ship design, I am originally a ship hydrodynamicist with PhD on nonlinear wave-induced ship motions and I never stopped researching and publishing on ship hydrodynamics in parallel to (and with emphasis on) ship design. I studied and worked for many years at TU Berlin, before continuing my career abroad, thus coming back to Germany and starting working in a predominantly hydrodynamic scientific environment outside academia is like *"back to the roots"* and looking for new professional challenges. The relationship between ship hydrodynamics and ship design I explained before, but why HSVA is the right place for the coordination of HOLISHIP needs still to be commented in the following.

HSVA is the largest maritime research centre of Germany and worldwide renowned for its long tradition and experience in ship model testing and studies on applied ship hydrodynamics. Besides its excellent experimental facilities, HSVA made in recent years significant contributions to the international state of the art in numerical ship hydrodynamics through its CFD department, allowing HSVA to become a major provider of related services to the national and international maritime industry. This is supporting a more general trend of all major model basins worldwide, namely to shift a series of services from tedious and costly physical model testing to numerical simulation studies (Virtual Towing Tank). Whereas in the past, when dealing with a ship design leading to a construction project, hydrodynamic investigations and hull form optimisations were (almost) exclusively done by model experiments on the basis of (at best) few design variants, nowadays more and more numerical CFD studies are complementing the conducted physical model experiments, allowing the investigation of more design ▶

alternatives. This trend is anticipated to further increase in the years to come and model basins will need to be more versatile with respect to the offered services to keep competitiveness in a very challenging and strongly volatile market. I was inspired by HSVA's motto *"Setting the Standard for Ship Optimisation"* when I first talked to Dr. Jochen Marzi, the head of the CFD department of HSVA, about the HOLISHIP project, and the chemistry in our communication worked immediately and obviously effectively by winning this project award.

HSVA: HOLISHIP will run for the next 3.5 years from now on. What will we have available at the end of this period and will it have an immediate effect on the design of ships in 2021+?

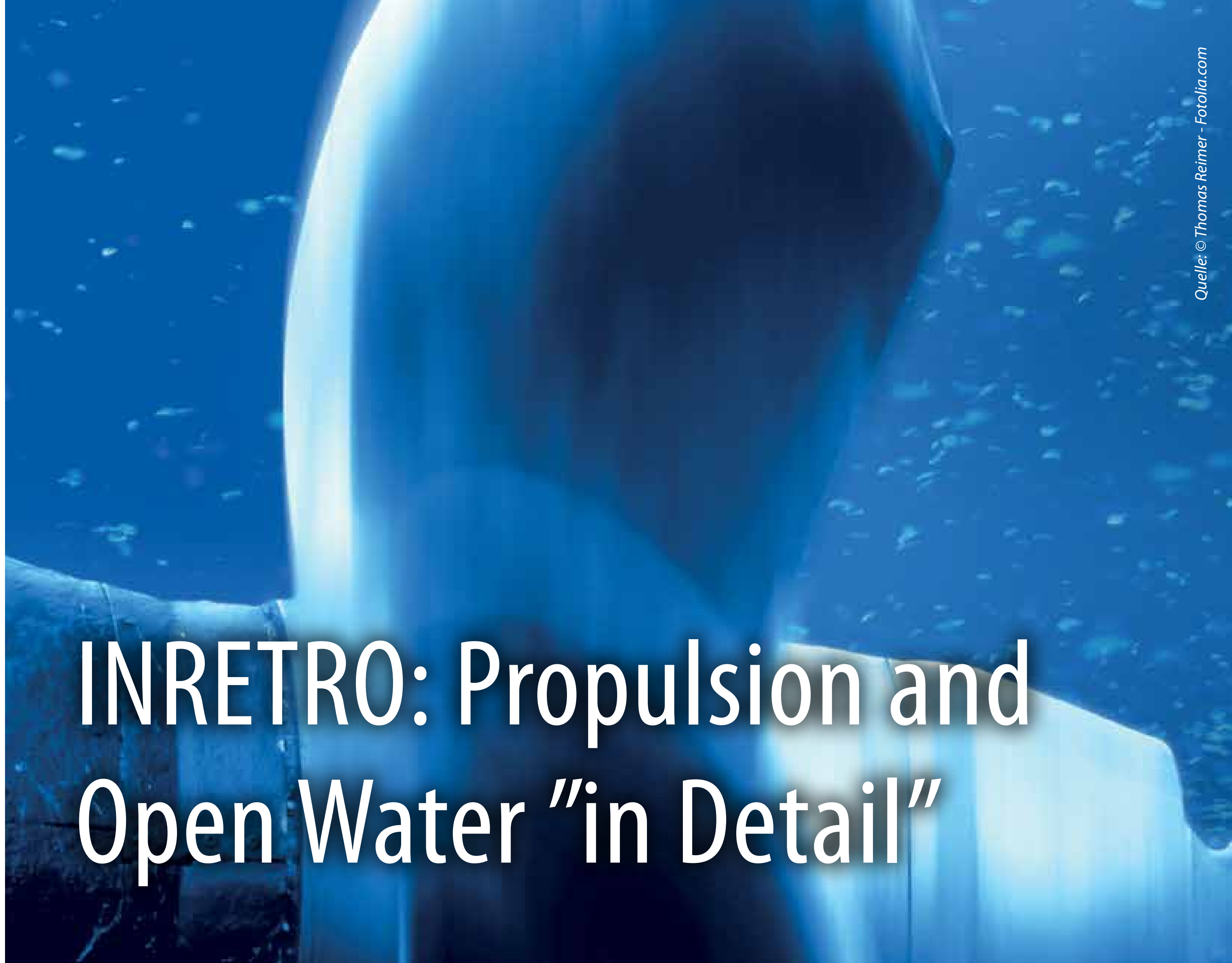
The project plans and will be delivering two integrated design software platforms, namely one on the basis of Friendship Systems' CAESES® software platform and the 2nd one on the basis of the DLR's CPAX® software platform. The CAESES software platform will be our prime platform for ship design, whereas the CPAX platform will be used for the virtual modelling of time dependent ship operations (Virtual Demonstrator). The project plans nine (9) application studies on various ship and floating structures design and operational scenarios, defined and led by the participating industry. This industry will be the first to experience the impact of the project's developments on the design and operation of future ships. Of course, participating software developers, vendors and design offices will be benefitting in parallel from the new software environment to address new design challenges, while being very competitive in the international market and HSVA will be among them. I anticipate that HSVA will significantly strengthen its ability to work on complex design optimisation projects, to conduct optimisation studies in short lead times, to have a smooth integration of its major software tools into more general design software packages and last but not least to have a seamless and efficient interaction with its customers and their IT tools/environment.

The adoption of such an innovative approach by the maritime industry in general, including shipyards, however, will need some more time to become reality, judging from past experience with the introduction of innovations to the maritime industry. I am modestly thinking that existing practices will be not given up without persistent dissemination of the generated new knowledge from project's side, the implementation of the HOLISHIP approach in university curricula and the continuous/postgraduate training of practicing engineers. Among other dissemination activities, this is the reason why we planned the edition of a reference book on the holistic approach to ship design (the HOLIBOOK), the first volume of which will published by SPRINGER Publ. and appear in late 2018 (volume 2 with the application studies will follow in late 2020).

HSVA: Thank you very much. ■

1. Papanikolaou A., "Holistic Ship Design Optimization", Journal Computer-Aided Design, Elsevier, Vol. 42, Issue 11, 2010, pp. 1028 –1044

2. Priftis, A., Papanikolaou, A. and Plessas, T., Parametric Design & Multi-Optimization of Containerships, Journal Ship Production and Design, SNAME, No. 3, August 2016, pp. 1–14 http://dx.doi.org/10.5957/JSPD.32.3.150029



INRETRO: Propulsion and Open Water "in Detail"

The numerical towing tank, which would directly handle the full-scale ship, may still be considered as a vision. However, if experimental and computational fluid dynamics (EFD and CFD) are allowed to interact the physical and the virtual tank can support each other.

by Heinrich Streckwall, Yan Xing-Kaeding and Thomas Lücke

In particular CFD may help to review the final step linked to propulsion test evaluation, namely the scaling of all measured quantities. Applying CFD the European project INRETRO focuses on propeller / hull interaction and the various ways one may reference propeller open water (POW) tests in this respect.

The acronym INRETRO includes the propeller retrofit idea as the preparations to substitute an existing propeller may request support from the numerical towing tank. One of the retrofit scenarios treated within INRETRO limits the experimental effort to POW tests, skips the re-building of the ship model and treats self-propulsion purely numerically. Besides HSVA, the propeller manufacturer MMG from Germany, the model basin CTO and the ship-supplier SCANA-Zamech from Poland as well as the ship-supplier MILPER from Turkey are sharing work within the project.

Having addressed in the above the interaction of EFD and CFD, this idea needs guidelines and practice to reach application level. With the focus on the propeller the INRETRO work plan covers …

- **Ruling and practicing the numerical treatment of POW setups**
- **Ruling and practicing the numerical propulsion simulations**
- **Ruling and practicing the complete numerical treatment of propeller retrofits**
- **Ruling and practicing the design and analysis of pre-swirl stators**

▶

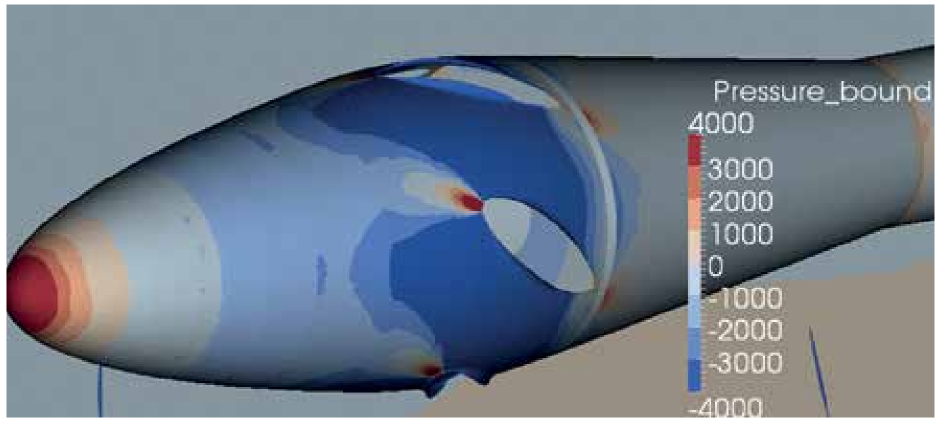


Figure 1: Pressure on nose cap of CPP 1304 in POW mode (flow from left to right)

Results linked to the first three items in the above list of topics were presented among the partners during face-to-face meetings organized in Istanbul, Gdansk and Hamburg. Below we give results presented by HSVA during these meetings and try to deduce general conclusions from our numerical work. Most of these findings were also published in the NuTTS 2016 symposium. At HSVA for all numerical investigations the in-house RANS-solver ***FreSCo⁺*** was applied.

Starting with the numerical simulation of POW setups we can definitely recommend to stick to the experimental details closely, otherwise a comparison of test results and calculated quantities will be misleading. The larger the boss dimensions of the propeller the higher the risk to invoke errors when doing manipulations in the hub area for convenience. Especially the shaft orientation, the nose cap details and particulars on gaps between rotating and fixed parts of the setup turned out to be relevant. A sample for a typical pressure field developing on the nose cap and entering the total thrust balance is given in Fig. 1. In this view the blades have been removed to isolate the cap surface but they actually trigger the pressure on large parts of the cap. CPP 1304 referenced in Fig. 1 belongs to the Potsdam Model Basin, was subject to several comparative calculations and recently entered an ITTC benchmark call on propeller scaling.

Following the ITTC benchmark instructions and including a full scale POW scenario accordingly we registered a clear tendency. We obtained nominally higher scale effects on thrust (thrust coefficient KT) than on torque (torque coefficient KQ) while the full-scale efficiency was behaving as expected (Fig. 2). Introducing a hydraulically smooth blade surface also for full scale the efficiency enlarges considerably from model to full-scale. Applying the ITTC recommended procedure to our calculated model scale KT and KQ, which accounts for a 30 microns surface roughness, the scale effect on efficiency turns out to be minor. Considering a new built full-scale propeller one may assume that the 'truth' lays somewhere inbetween and the request for a turbulence model sensitive to surface roughness becomes relevant. The turbulence modelling options supplied with ***FreSCo⁺*** are currently extended adequately.

Not referenced in Fig. 2 the numerical POW studies included an "artificial" propeller showing negligible viscous losses, modelled via a "slip wall" boundary condition applied to the blade surface.

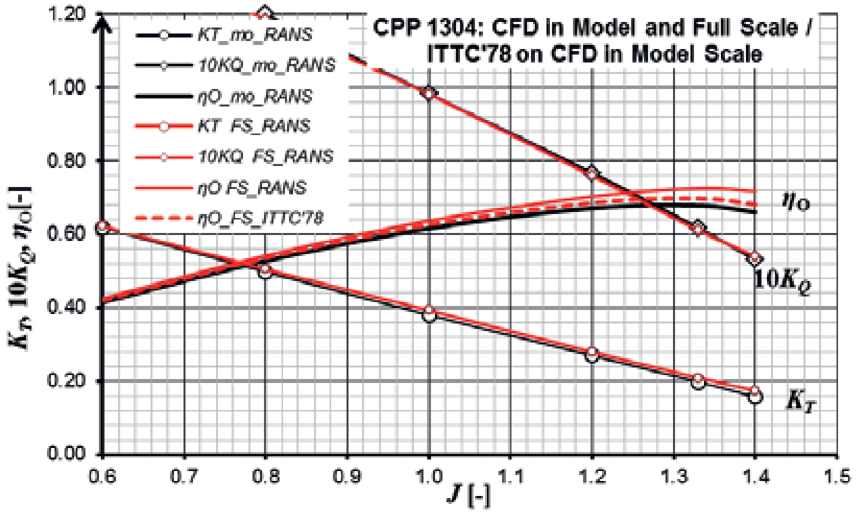
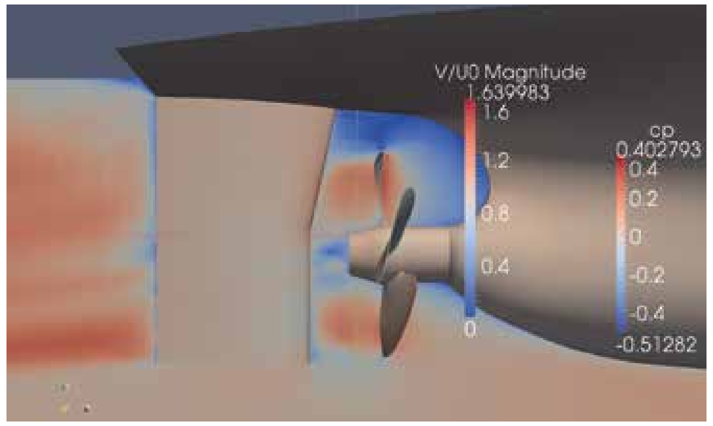


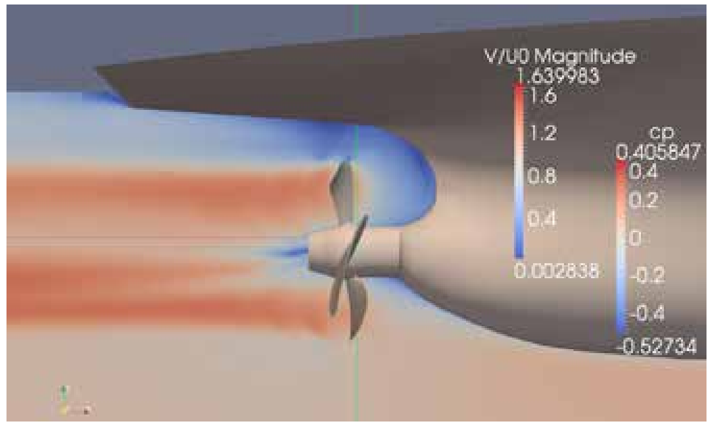
Figure 2: Open water results for 2 scales of CPP 1304

To establish a link to propeller / hull configurations, POW simulations were based on two principally different setups, namely putting propeller and environment in one domain rotating on the whole and – alternatively – placing the propeller into a rotating sub-domain located in a static environment connected via so-called sliding interfaces. The analysis could be done both ways without noticeable difference. This gave confidence that also the self-propulsion condition can be treated accurately.

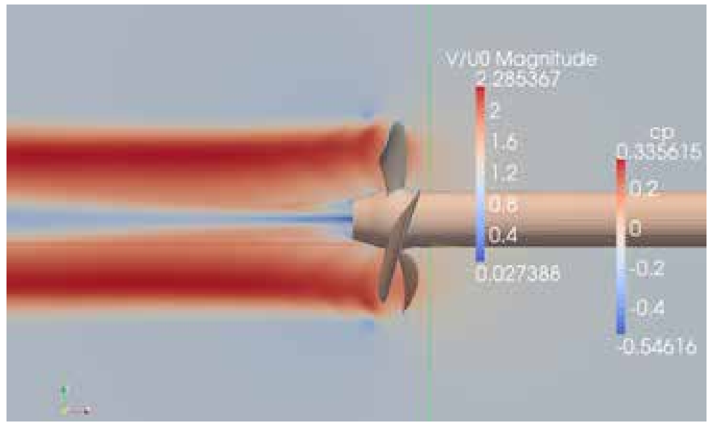
As propellers represent wake-adapted designs, this feature should be reflected when comparing POW and in-behind performance. Within the INRETRO project we aim at numerical approaches to quantify differences between these two modes. Focusing on the propeller efficiency encountered in both modes, the factor "*relative rotative efficiency* = η_R" – denoting the ratio of these efficiencies – represents a challenging quantity. η_R is known to range close to 1.0. Generally the numerical approach includes the chance to detect spurious influences on η_R, potentially leading to false understandings. In order to minimize numerical effects, it is reasonable to work with a unique and exchangeable propeller sub-grid rotating either in the POW environment or behind a hull. Treating propulsion and focusing on propeller / hull interaction we applied the simplification of a double body setup, implying that hull forces due to wave resistance have to be deduced from other sources.



+rudder: weff=0.416 (+12%), FxCap/FxProp=+1.24%



w/o rudder: weff=0.372, FxCap/FxProp=-0.07%



POW J=0.45, weff=0.0, FxCap/FxProp=-0.82%

Figure 3: Velocity distribution V/U_0 in planes cutting propeller axis; ***on top:*** *in-behind condition with rudder, mid: in-behind w/o rudder, bottom: for POW setup*

The numerical work on self-propulsion included a Single-Screw case where experimental data and all details on propeller and hull were available. It was natural then to prescribe speed and shaft frequency according to the model test values. For a consistent comparison of POW mode and in-behind mode we also considered – and actually recommend – a reversed open water setup, causing minor extra effort within a numerical approach. In this case it is especially no matter of discussion how thrust identity, which represents the basis for η_R, should be defined. In the reversed POW mode hub and hub cap can be taken over from self propulsion and the sum of forces from all parts can be used to define thrust identity. Besides this, the unique propeller sub-grid can be used in POW mode as well as in behind mode. Naturally forces and moments taken from the in-behind mode must represent time mean values.

Fig. 3 shows a setup for a POW analysis in reversed mode (bottom) and related in-behind setups with the same hub cap involved (top with and mid w/o rudder). As expected, the longitudinal force acting on the propeller cap turned out to be a resistance at POW-condition (-0.8% of KT) as well as for the in behind case w/o rudder (-0.07% of KT). But due to the ▶

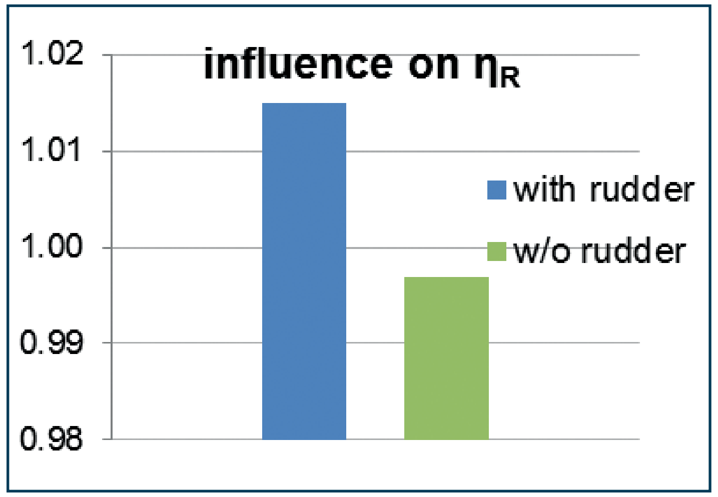


Figure 4: influence of the rudder onto η_R at ship speed Vs=11 kts

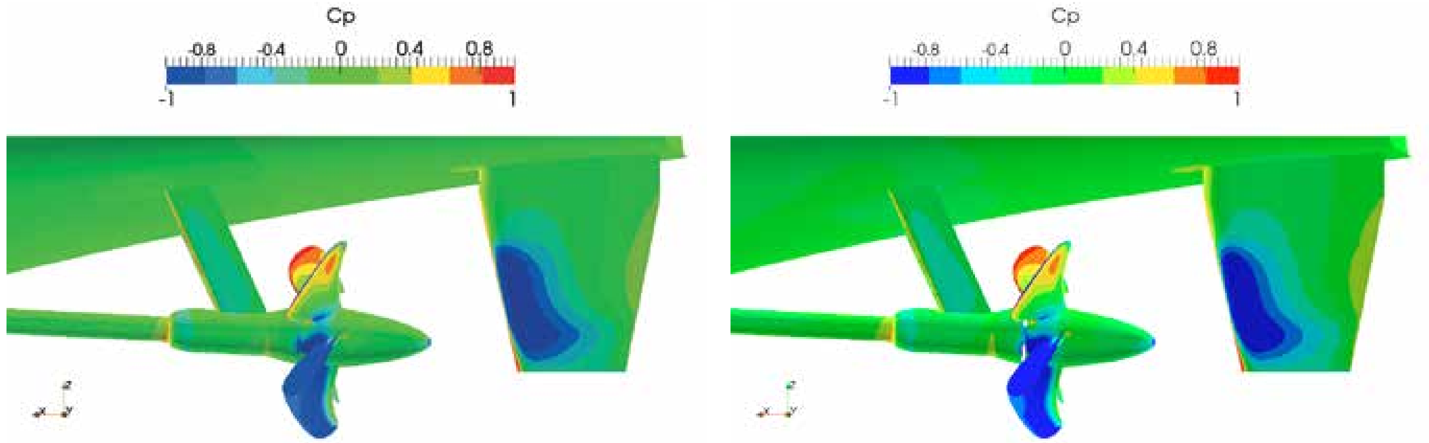


Figure 5: Gap effects influencing thrust of twin-screw propeller in propulsion mode: without gap (left) and with gap (right)

presence of the rudder the hub vortex became less concentrated and the force on the cap became a thrust (+1.2% of KT !). This explains to some extent the influence of the rudder onto η_R, which increased in this case by 1.8%, see Fig. 4. The main contribution seems to come from this local force difference on the propeller cap, rather than from the global propeller-wake interaction. The latter is often referenced of being the quality index for successful propeller wake adaption.

In a Twin-Screw sample case we analyzed an artificial set up of hull and stock-propeller. Fortunately the combination of the DTMB hull 5415 (CAD data were available for all INRETRO partners) and propeller CPP 1304 (as a benchmark also assessable for all partners) turned out to represent a reasonable arrangement. However, as they were never tested together, we had to find an efficient way to reach the numerical propulsion point at a given speed. In this case it was natural to refer to a numerical "British Method", the latter known as an alternative to standard propulsion tests. Due to a reasonably linear relation of non-balanced hull force and thrust to be introduced for compensation, two "shots" (i.e. two shaft speed settings) are usually sufficient to reach self-propulsion.

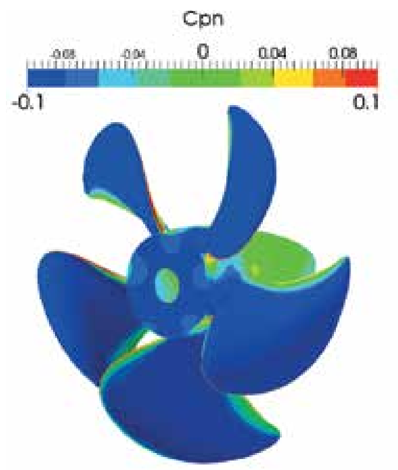


Figure 6: Negative pressure on the rotating part of gap increasing the propeller thrust

As again the CPP 1304 was involved it deemed worthwhile to check propeller forces in detail and investigate gap effects. The treatment of the gap between the hub and the strut barrel (modelled or not) will influence the self-propulsion point (in view of the resulting shaft frequency) but it will affect the thrust dedicated to the propeller unit. After having first closed this gap artificially we modelled the gap according to a typical implementation for model scale tests (Fig. 5). We recognized that a negative pressure dominates the gap area due to the suction effect of the propeller blades (Fig. 6), resulting in an increase of the propeller thrust by about 6-8% when the force on the gap is added. The lower the RPM, the higher this ratio develops. In return, a corresponding resistance

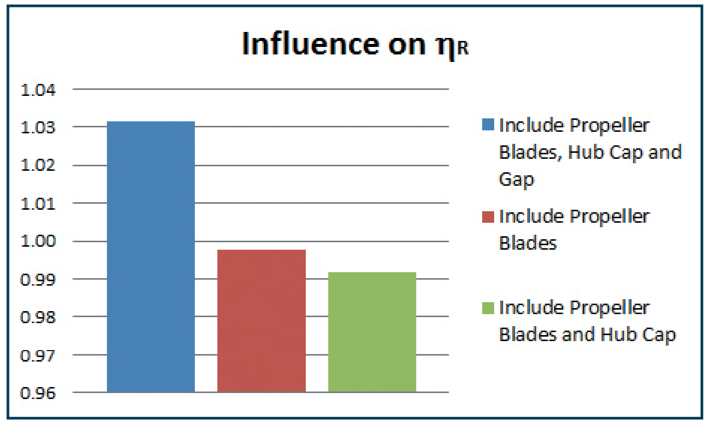


Figure 7: influence of the gap force (left column "with" / other columns "w/o") onto η_R

force has been detected for the ship so that the force balance for the whole system does not change. By including the gap and following the model test evaluation procedure, we identify an increase in η_R by about 3.5% (see Fig. 7).

Summarizing one may state that more strictly than initially expected the system of blades and hub must be taken as a unit and geometrical details around the hub must be carefully reflected to allow for a true comparison of EFD and CFD. ■

Figure 1: Different Propeller Caps tested in HYKAT

How Much Can a Hub Cap Save?

PBCF (Propeller Boss Cap Fins), ESCAP (Energy Saving Cap), EnergoProFin, ... and all kinds of energy saving propeller hub caps with fins are state of the art and become more and more indispensable with respect to environmentally and ecologically conscious behaviour in naval architecture.

by Julia Müller

The daily business of a model basin is to measure and predict energy-savings and to help owners with the wide variety of energy saving devices. But in the end it comes all down to reducing costs.

The in-house research project "HYTES" reviews the possibility of testing hub caps with fins in the HYKAT.

Hub caps with fins are usually designed on experience and can hardly be tested in a model basin. During the propulsion test the ship speed is – generally speaking – too slow, thus the Reynolds number is too low. During the standard open water test, which can be run faster, the propeller operates upstream of the dynamometer and has a hemispherical cap. Since the hub cap with fins is only working behind the propeller, additional reversed open water tests need to be done with the dynamometer in front of the propeller and the influence of the boss cap fin needs to be calculated into the standard open water test. But in this case the ships wake is missing. These limiting factors do not apply in HYKAT. In the large Hydrodynamics and Cavitation Tunnel the whole model is installed and can be run up to water speeds of 8 m/s, so it is possible to run the propeller at a high Reynolds number – even higher than in the open water test – and in the ship model wake.

A hub vortex is caused by the joining boundary vortices of the different blades. Each blade develops an individual vortex – which consumes energy – these vortices merge behind the hub cap and form a concentrated vortex. The shape and intensity of this vortex depend on the type of the hub cap. Therefore a hub cap with the same amount of fins as the amount of propeller blades can diminish the joining and improve the propeller efficiency. Fig. 1 shows some of the ▶

propeller caps with fins which have been tested in HYKAT.

At the moment tests with boss cap fins are either done as explained above or tests with boss cap fins are just neglected. Nevertheless in the end those caps are mounted onto the full scale ship, without any information about the final power consumption.

For comparative tests in HYKAT the water speed in the tests section will be held constant, the propeller speed will be increased in steps, so that a wide range of propeller loadings can be tested. This is done with a conventional propeller cap and in a second step with the propeller cap with fins, at the exact same tunnel water speed and propeller speeds. At every stage all data, like thrust, torque, rotational speed, water speed and water temperature are recorded. Afterwards the evaluation is done and power savings can be calculated. For the evaluation it is assumed that keeping the water speed

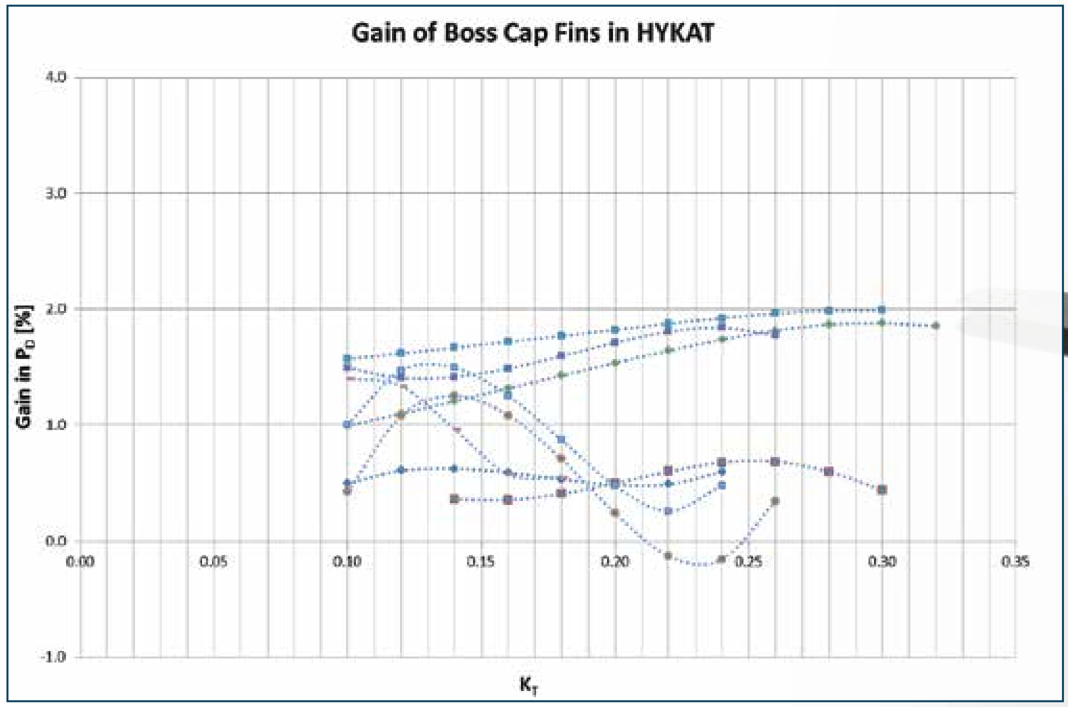


Figure 2: Gains measured in HYKAT

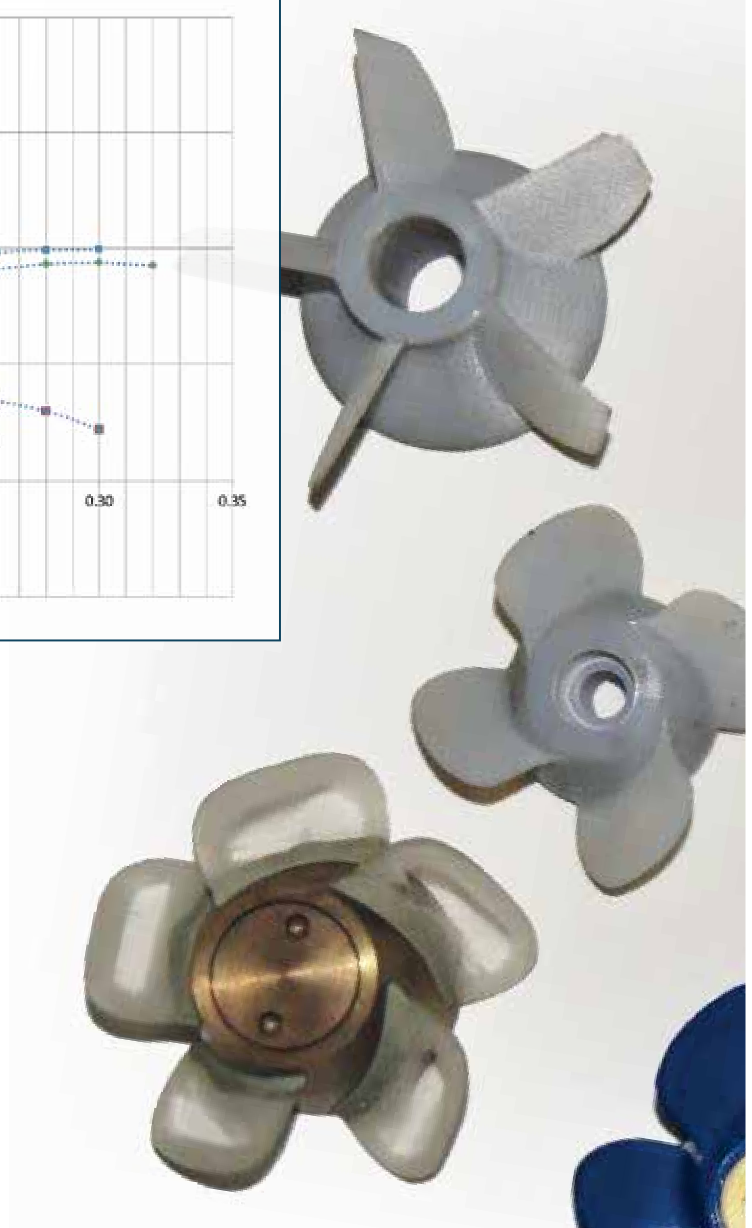
constant two slightly different thrusts will be measured, hence a delta value will be calculated. This method allows to measure different kind of energy saving devices mounted behind the propeller.

First test in HYKAT with different types of vessels (e.g. container vessel, motor yacht, bulk carrier and multipurpose vessel) have shown that the effect of the hub cap with fins can be sufficiently measured. Fig. 2 shows the gain for all tested vessels so far.

It can be seen nicely that all different caps work differently and have different behaviours over the range of tested propeller loadings. With those tests it is possible to find the propeller loading where the cap is working optimally and also were no gain will be achieved at all.

So far only few tests have been done, but the results are promising. It is now possible to test a power gain of different hub caps with fins. Additionally to standard cavitation test those tests can be easily done. Other advantage of testing propeller caps with fins in HYKAT is, that possible cavitation on the rudder, which is caused by a strong hub vortex, could be diminished by prove. It is also possible to test differently designed hub caps with fins and find the best design.

How much a hub cap saves can be measured together with cavitation tests. ■



Wind Tunnel Tests for German Multi-Purpose Vessel "Neuwerk"

Figure 1: MPV NEUWERK - Quelle: WSA Cuxhaven

Wind tunnel tests are sometimes required by HSVA customers for new building or conversion projects – be it for technical reasons like helicopter operations or comfort reasons for yachts.

by Henning Grashorn

HSVA does not have a wind tunnel and therefore sub-contracts these tests to our friendly competitor – the *Schiffbautechnische Versuchsanstalt in Wien GmbH* (Vienna Model Basin). The Vienna Model Basin has a long experience with wind tunnel tests and is one of the leading facilities for testing cruise liners, yachts and other vessels. As typical among model basins the cooperation is problem-free and as we think profitable for both sides.

The last HSVA project that was tested in the wind tunnel of the Vienna Model Basin was the investigation of the multi-purpose vessel "Neuwerk", operated by the "Wasserstraßen- und Schifffahrtsamt Cuxhaven" (WSA Cuxhaven) – a German authority responsible for the maintenance, security and development of a large part of German inland and costal seaways.

The vessel experiences problems by cause of exhaust gas on deck and near the superstructure – leading to health hazards for the crew and technical problems due to affected air inlets. To solve the issue it was decided to investigate the current exhaust funnel layout and find a solution for a modification.

The cause of the problem was seen at a first visualisation of the boundary layer – the exhaust pipes are too low and the exhaust gas remains inside the boundary layer (see Fig. 3).

To find a solution the model was modified several times in the area of the exhaust pipes and mast. In total thirteen smaller or larger modifications were investigated within the three-days testing period.

This shows the advantage of physical model testing compared to a numerical analysis. A model ►

Figure 2: Windtunnel at Vienna Model Basin
Source – SVA Wien

Figures 3, 4 and 5: Source – SVA Wien

modification is – depending on the extent – quickly done as well as the following investigation with several wind speeds and directions.

For the "Neuwerk" the solution was a new funnel/mast layout with much higher exhaust pipes and rearranged mast platforms. The comparison of the exhaust flow before and after the modification shows the improvement clearly (see Fig. 4 and 5):

The customer was supplied with a solution and guidance for the modification of the existing vessel.

We expect to continue the successful cooperation with the Vienna Model Basin. ■

In the last issue of NewsWave we presented HSVA's current research related to friction resistance and highlighted ways how to reduce this large contribution to overall resistance and energy consumption in the future. While advanced coatings, air lubrication and boundary layer control are promising technologies for the future, another aspect of ship resistance has received rather little attention in the past. Aerodynamic forces acting on the ship hull and superstructure have been largely disregarded, except for some special, typically high speed designs where they were considered relevant. However, this limitation is not true. Closer inspection reveals that especially smaller and slower cargo vessels have a significant contribution of aerodynamic resistance during real operational conditions. Tests for a cargo ship sailing at 14 kts in Bft. 5 headwinds indicate that the overall share of aerodynamic resistance can be as high as 20% of the total resistance. This indicates a growing relevance of aerodynamic resistance also for slower ships which is perfectly in line with the current trend towards "slow steaming".

AERONAUT Project Launched

Traditionally the Hamburg Ship Model Basin is active in the field of ship hydrodynamics. For more than 100 years HSVA helps customers to optimise the hullform and hydrodynamic properties of ships with respect to energy efficiency, operability and of course safety.

by Scott Gatchell, Jan-Patrick Voß and Jochen Marzi

Using model tests and increasingly so numerical methods a very high level of sophistication has been reached over time. While ship resistance and propulsion are still the most important aspects determining the efficiency and economics of most cargo vessels, targeted research and developments have helped to reach a pinnacle in traditional hullform design and optimisation of form related resistance, the central scope of a model basin. Today, the best vessel designs reach as little as 20% share of wave resistance and very little can be done to further improve this. On the other hand, further aspects of resistance influencing the energy efficiency of ships need a lot more attention today.

As HSVA claims to provide complete customer services it is only consequent to put a new focus on aerodynamic resistance, the computational tools to predict these forces and to investigate means to improve this part of the overall ship resistance. Dedicated aerodynamic computations using advanced CFD models have been introduced in the overall service portfolio already a while ago. These focus mainly on exhaust gas propagation, comfort or helicopter operation, and a number of analyses have been performed specifically for research vessels, yachts or naval applications. The aim to improve aerodynamic resistance adds a new quality.

As a consequence HSVA launched the research project AERONAUT which is funded by the federal ministry of economics and technology as part of the German national maritime programme.

Following inspiration from other modes of transport, the three year project will develop aerodynamic appliances and optimise the air flow around the superstructure of ships. The aim of AERONAUT is a significant reduction of the wind resistance of ships in order to reduce the fuel consumption and greenhouse gas emissions. Ship superstructures are typically based on geometrically simple shapes in order to enable a cost-effective production. These simple designs often come along with a rather high air resistance, resulting in an increased power requirement. ▶

To reduce the aerodynamic resistance of ships AERONAUT will develop and optimise a range of customised attachment parts in the form of spoilers, baffles and casings for various configurations of superstructures. This will not only consider the aerodynamic efficiency, but also the practicability in ship operation. Further attention will be paid to manufacturability and the structural design with fibre composites.

CFD computations using ***FreSCo$^+$*** bridge the gap between traditional model testing and full-scale validation tests. The capability to compute air flow in full scale provides a more accurate understanding of the flow dynamics. Advanced computing methods, such as Detached Eddy Simulations

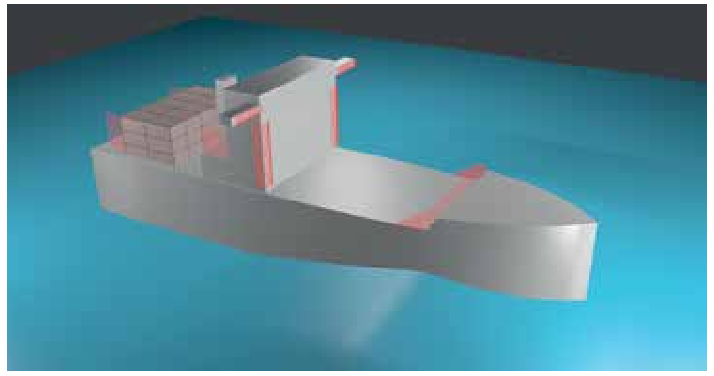


Figure 1: Illustration of possible sites for customised attachment parts, shown in red

(DES), provide even more detailed local flow information than the commonly used unsteady RANS (URANS) simulations.

To address all challenges of AERONAUT, HSVA has joined forces with partners TUHH (numerical predictions and wind tunnel validation), CMT (structural and material analysis), Knierim Yachtbau (prototype manufacturing of appliances) and operator Jüngerhans who will support the developments and test prototype appliances on board of a container vessel. Over the course of this project a specific set of aerodynamic parts will be developed, manufactured and installed on a container ship. Onboard monitoring systems will be used to perform comparative measurements of the fuel consumption in operation in order to validate the basic concept. AERONAUT will provide a step change in maritime aerodynamics and is supposed to open up a completely new business field. ■

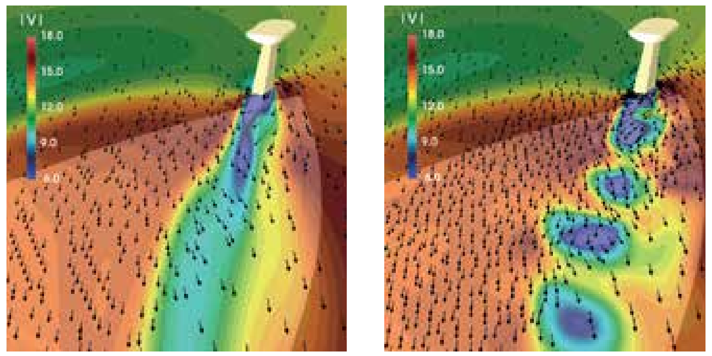


Figure 2: Comparison of local flow details: URANS (left), DES (right)

Figure 3: PICTOR J during passage of the Kiel Canal

Figures 5 and 6: Planned test ship for full-scale application (left), model for CFD computations (right)

Figures 7 and 8: Details at forecastle shelter: test ship (left), model for CFD computations (right)

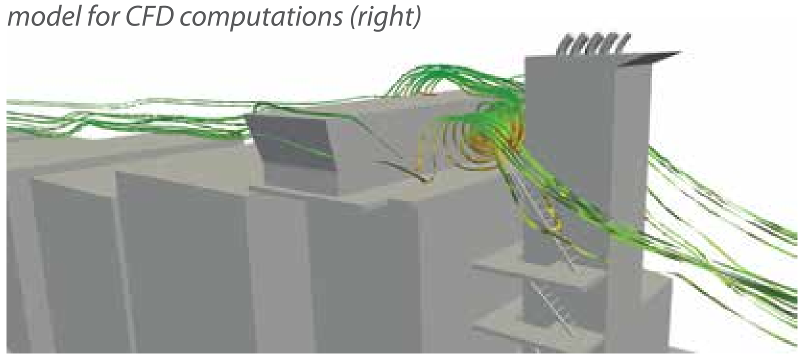


Figure 9: Results from a preliminary computation: streamtrace ribbons, coloured according to local flow velocity

Ink-Flow-Tests: What to do when Fluctuating Measurement Results are Observed

HSVA is performing a great amount of ink-flow tests per year, most of them with a normal course and reliable measurement results.

by Katrin Lassen

Occasionally, we are observing inconsistent measurements or unusually fluctuating results. First actions that are taken in such a case are certainly to check measurement equipment and measurement routines, model conditions and the installation situation.

If neither physical nor human error can explain the inconsistency, then one may assume a hydrodynamic effect on the measurement. It may be influenced by unstable flow phenomena affecting the inflow to the propeller, to an ESD or more generally the flow around the stern area especially in regions with high pressure gradients. The unstable flow leads to the fact that the equilibrium of propeller thrust and hull resistance is no longer stationary. This could be caused by boundary layer or flow separation, when the fluid detaches early from the model's hull and instead takes the form of eddies and vortices. The effect on the model is an increase in model resistance and therefore higher necessary thrust. The disturbed flow is diminishing the effect of an ESD and is likely to increase the necessary propeller torque even further. This is especially the case for full block vessels running at low Froude numbers.

To deal with this situation and to eliminate the need for guesswork, HSVA constructed a device which is quickly ready for use and cost-effective. It is easy to use during on-going tests and without any impact on the current measurement results. We are using a lance which is emitting ink into the water near critical locations. The process is filmed by an underwater camera. Regular flow as well as a potential flow separation can be made visible. The ink is biodegradable and has no impact on the water quality.

With the help of this device, uncertainties regarding the test results can be cleared up in an economical and quick way.

On-going research on this topic is trying to find a solution to increase reliability of the correlation process for these kinds of model tests. ■

Figure 1: Flow separation at the stern area, detected with the help of an Ink Flow Test

Manoeuvring and Dynamic Positioning FAQ

Many of our customers order resistance and propulsion tests at HSVA on a regular basis. These and also new customers are kindly invited to take advantage also from our capabilities to predict the manoeuvring or DP performance of their ship designs.

by Henning Weede

This helps to ascertain acceptable manoeuvring and course keeping performance in compliance with the IMO standards, to assess the heeling angles, to limit efficiency losses due to rudder action for course keeping and to determine the types and arrangement of thrusters for DP. During this process, we can suggest design modifications, if these turn out to be necessary, or for the improvement of the performance of the vessel.

Sometimes prospective new customers sending us inquiries on manoeuvring tests, try to anticipate details they know them from other towing tank institutions. This sometimes makes it difficult for us to offer them the advantages of the well-proven HSVA methods using the Computerized Planar Motion Carriage (CPMC). Therefore, we have gathered a collection of useful information about our capabilities in the style of Frequently Asked Questions (FAQ).

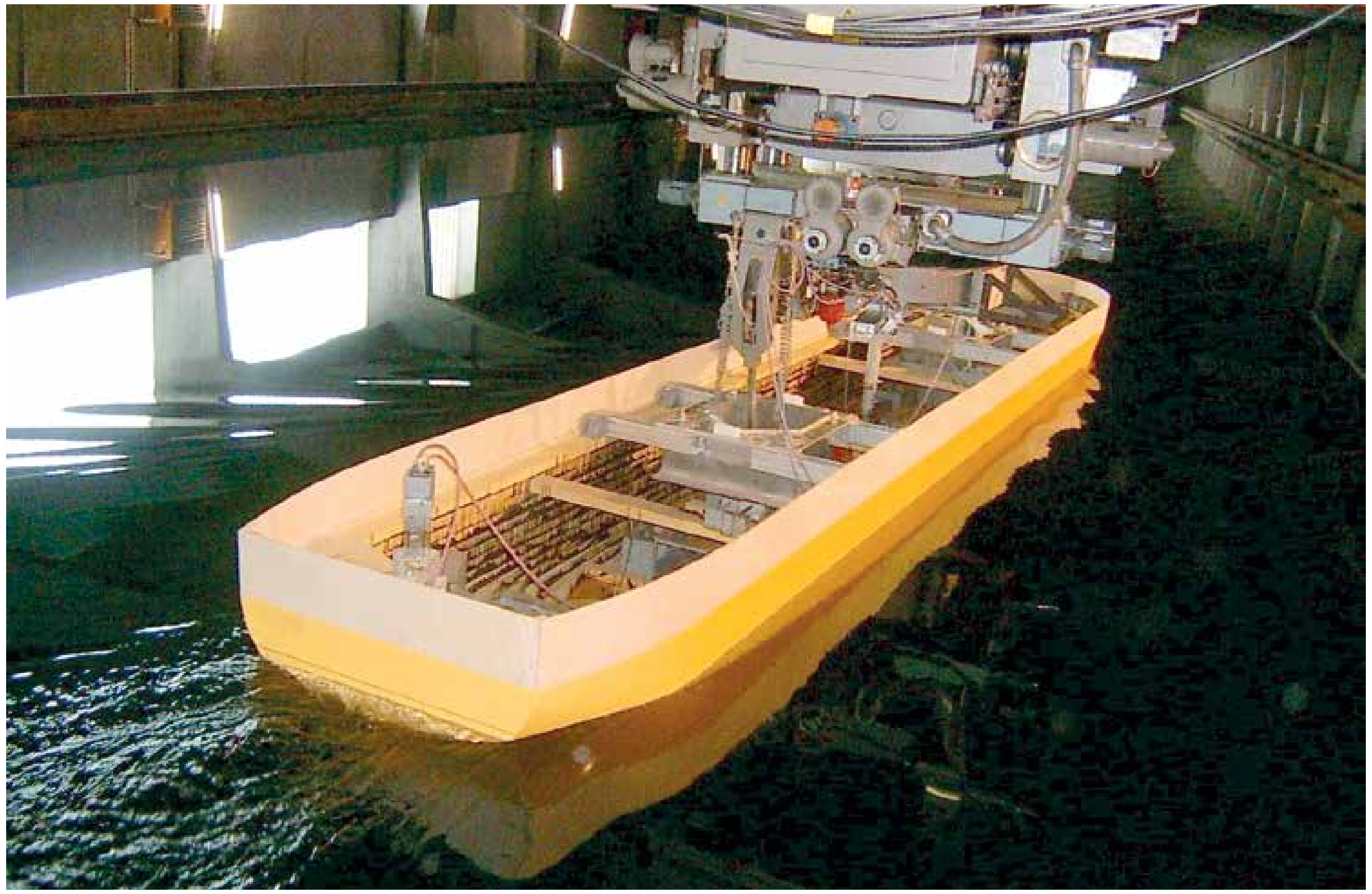


Figure 1: Model zigzag test

Q: Which rudder manoeuvres must a ship be able to perform?

A: The IMO resolution MSC.137(76) defines limiting values for the overshoot angles in the 10°/10° and 20°/20° zigzag tests, the initial turning ability, the tactical diameter, and the advance at 90° change of heading. The accompanying explanatory notes MSC/Circ.1053 define a maximum allowed rudder angle range for yaw instability in the spiral test.

Figure 2: Manoeuvring fin under the stern bulb

Q: What are the most common manoeuvring deficiencies?

A: Very full tankers, bulk carriers and similar vessels sometimes fail to keep the first overshoot angle in the 10°/10° zigzag test within the permissible limit or are unstable in yaw within an excessive rudder angle range. The other extreme may be fast and slender vehicles, which are stable in yaw, but in some cases exceed the permissible turning circle dimensions.

Q: How can I improve the manoeuvrability of a tanker or bulk carrier?

A: The most effective appendage to reduce the overshoot angles and yaw instability consists of a triangular fin that fills the gap between the stern bulb and the base line. To support propulsion, its aft side can be made asymmetrical with a chamfer according to the propeller sense of rotation. A smaller favourable effect can be expected from a rudder ending plate. As to the lines design, it should be avoided that too small bilge radii in the aft body cause a complete flow separation leading to adverse effects on the inflow to the propeller and rudder.

Q: How does HSVA contribute to ascertain sufficient manoeuvrability?

A: In order to determine whether the ship will fulfil the IMO resolution MSC.137(76) a combination of model tests and numerical simulations is applied. Model zigzag tests with small to maximum rudder angles produce data to determine the coefficients of empirical motion equations for surge, sway, yaw and roll. Integrating these in time domain and feeding the appropriate rudder angles into the algorithm can simulate all relevant rudder manoeuvres, also turning circles and a spiral test. In most cases the 10/10 and in some cases the 20/20 zigzag test is part of the tests and doesn't need to be simulated. A clear description of the method is contained in each HSVA report on manoeuvring model tests. The method has been validated with full-scale results.

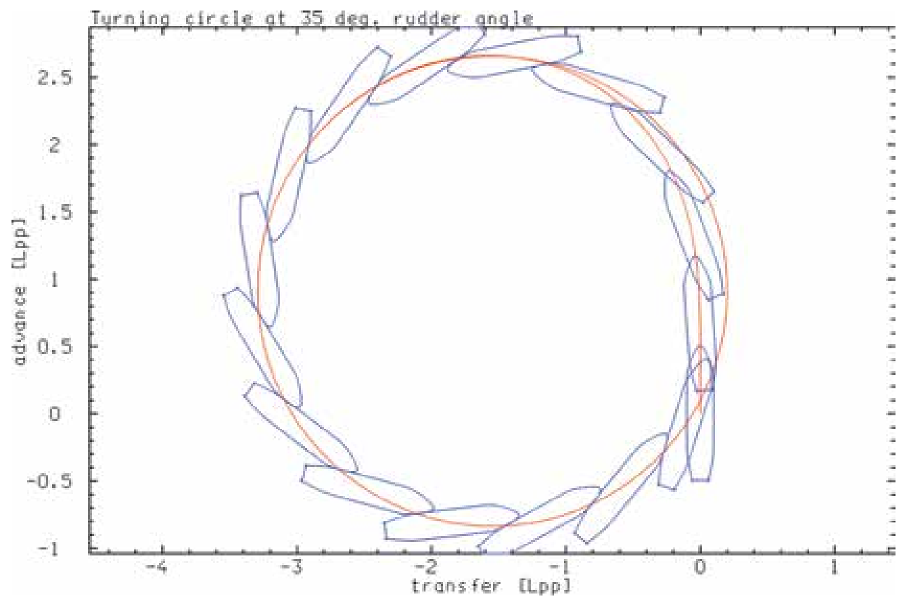


Figure 3: Turning circle simulated from zigzag test data

Q: What problems can HSVA fix during the tests?

A: If insufficient manoeuvring performance can be expected prior to the tests, HSVA can prepare alternative appendages and modify the stern configuration during the tests. ▶

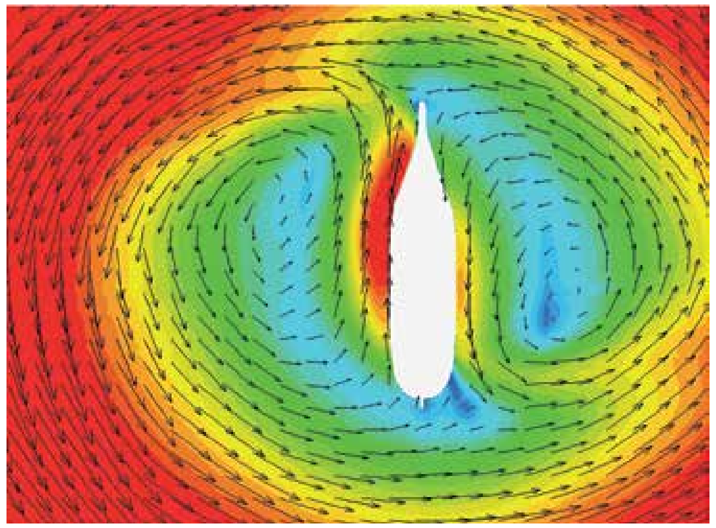


Figure 4: RANS calculated turning hull

Q: Can I order manoeuvring model tests instead of calculations?

A: It doesn't make sense to omit any calculations because not all relevant manoeuvres fit into the towing tank and thus must be simulated. The use of a sufficiently small model to perform manoeuvres directly in the tank can result in severe scale effects. Instead, HSVA works with large models and thus minimizes the scale effects.

Q: Can I order manoeuvring calculations instead of model tests?

A: There are two different types of calculations. Modularly assembled estimations of hull forces, rudder forces, propeller characteristics and interactions are one type. This is not very reliable and can be inaccurate especially in case of non-slender ships, like bulk carriers and tankers, which have a tendency to be unstable in yaw. These calculations cannot replace methods based on model tests. Nevertheless, HSVA has the software for such calculations. RANS calculations are the other type. Yes, technically they can replace model tests, but in the past they were more expensive. HSVA is continuously working to make manoeuvring RANS calculations more economic.

Q: Does HSVA perform manoeuvring sea trials?

A: HSVA cooperates with an experienced subcontractor, who has the required knowledge, experience and hardware to perform and evaluate manoeuvring sea trials.

Q: Can I omit manoeuvring model tests and calculations as there will be sea trials?

A: You decide this at your own risk. In case of tankers and bulkers, it may turn out that the ship doesn't comply with the IMO standards, which would lead to very expensive modifications on a ready built ship. The IMO standards cannot always be applied literally to full-scale manoeuvring tests without the concern that there might be a certain risk of capsizing because of large roll angles caused by large centrifugal forces. And in case of many ships, it is not possible to perform the sea trials on scantling draught according to IMO.

Q: Can I compare manoeuvring model test results with full-scale sea trial results?

A: Only under one pre-requisite: The manoeuvring model tests and simulations are required once on scantling draught according to IMO, and once on ballast draught for comparison with sea trial results. It is not possible to take model test results on scantling draught and to obtain simulations on ballast draught from them. Model scale results on scantling draught are used to check the compliance with the IMO standards. Full scale and model scale results on ballast draught are compared with each other to verify that the simulation results based on model tests correspond to reality.

Q: What does HSVA do against scale effects?

A: First of all, HSVA uses large models for manoeuvring. Additionally, HSVA can apply a longitudinal computer-controlled skin-friction correction force on the model. HSVA can also let the computer to control the propeller revolution rate according to defined engine characteristics. Normally, these two counter-measures against scale effects are not necessary.

Q: How can I ascertain good harbour manoeuvring?

A: For harbour manoeuvrability, the ship must be able to crab (for berthing or un-berthing) and to turn on the spot under the influence of wind loads. HSVA's methods to investigate this are the same ones as for DP addressed in the next questions. The simulation of steady crabbing and steady turning based on model test results is sufficient in most cases. Nevertheless, HSVA can also simulate the whole process from harbour entry to berthing and from un-berthing to harbour exit once the required model tests have been done.

Q: Must I perform model DP with wind and waves if my vessel needs DP capability?

A: No. The usual way to ascertain DP2 or DP3 capability according to the IMO guidelines MSC/Circ.645 or corresponding rules of a classification society consists of a steady simulation, called dynamic positioning capability study. This is a calculation that requires model tests to determine some of the component loads.

Q: Can HSVA feature a DP scenario in model scale?

A: Yes, even in ice. HSVA has a model DP controller for up to eight thrusters that can operate either with an algorithm provided by the customer or with its own algorithm. It can be used in the ice tank, e.g. in managed ice, or in the large towing tank in waves. A current is featured by oblique towing. Wind can be featured by substitute means. Normally, such tests are not necessary to ascertain DP capability.

Q: How does HSVA perform a dynamic positioning capability study?

A: HSVA determines the characteristics of the main propulsion system by captive model tests. Many different propulsion system types can be modelled. Azimuth thrusters placed elsewhere are tested accordingly. The characteristics of tunnel thrusters normally require no model tests because their specific thrust (kN/kW) can be estimated with a good accuracy and reliability. If a current is taken into account, the model tests include oblique towing tests to determine the hull loads. Wind loads are estimated from literature, but HSVA can also order wind tunnel tests at a subcontractor. Drift forces due to waves are calculated with a panel method. Within a subsequent calculation, for each environmental load direction an appropriate combination of thrusts, steering angles and propeller pitches is sought automatically by the optimization algorithm to obtain a surge, sway and yaw equilibrium at minimum power consumption. HSVA has a thrust allocation algorithm that finds the optimum, that is, minimum power intake, even in case of very redundant and complicated combination of many types of thrusters.

Q: Can HSVA determine the Environmental Regulatory Number (ERN) of my ship?

A: Yes. The basic dynamic capability study, which takes pre-defined environmental loads and determines the required thrusts and powers, does not include this. At additional expense it is possible to determine the parts of the ERN number defined by pre-defined powers of the thrusters. The ERN describes the ship's

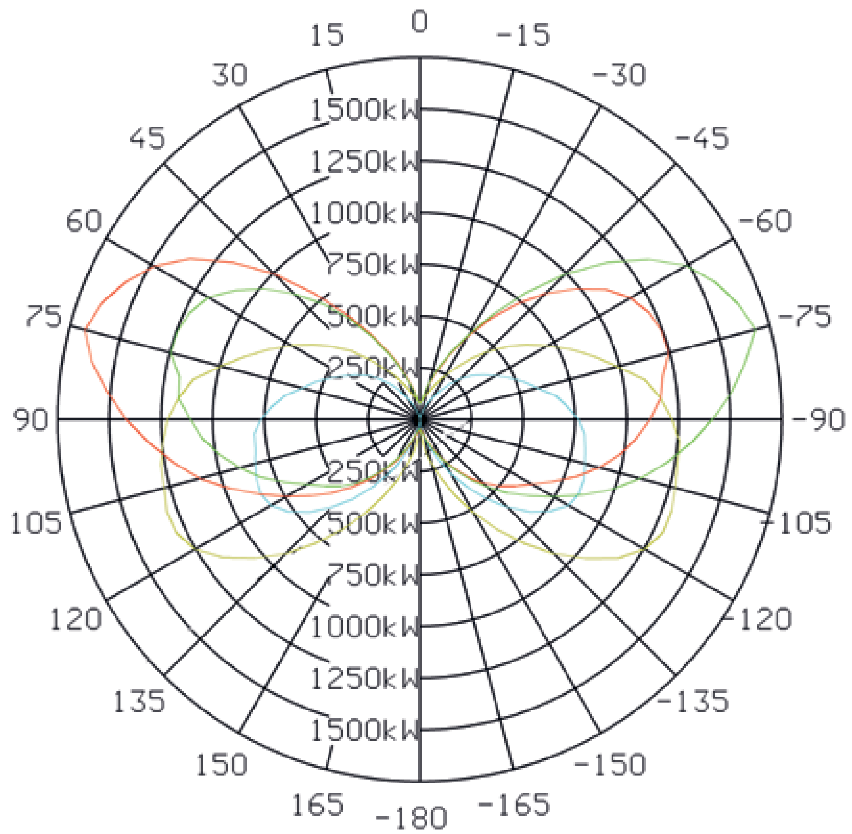


Figure 5: Dynamic Positioning Capability Plot

DP capability as defined by DNV-GL in their Rules for Classification.

Q: Can HSVA help me to decide types and positions of the thrusters before design?

A: Yes. In case of lack of an existing design and corresponding model test results with it, estimate DP capability studies can be based on statistical data from other ships rather than custom model tests. This can help to decide the basic arrangement of main propulsion system and thrusters based on economic considerations within a compromise with transit requirements.

Aaaand action! – Introducing the New Video System at HSVA's Large Towing Tank

Since many years HSVA offers its customers video recording services for most tests in the large towing tank. Video recordings are very useful for general documentation, but also have a big advantage in case customers or owner side cannot attend the tests directly.

by Sören Brüns

The videos show the ships wave systems at the different tested speeds / draught combinations and allow judging the ships behaviour in these conditions.

The first video system did a good job for many years and was state of the art at the time of its introduction. But time is moving on and technology is developing constantly. Now we set our system up-to-date with new hardware and automated post processing workflows.

The old SDTV with a resolution of 768 × 576 was already out-of-date for several years. The post processing had been done manually and was time consuming. Our aim was to improve these two matters: Where we used to have two remote controlled cameras looking to the model from the side we now have three cameras recording in HD [1]. Instead of doing a pan shot from bow to stern and back, we now can present our customers three different views simultaneously in one video utilising a split screen in the video clip. Like shown in the video snap shot in picture [2] the top half of the video is permanently showing the full side view of the vessel sailing. Below detail views of the bow wave and stern wave system can be observed. After half recording time the fourth, the transom camera picture, is displayed in the lower left frame. That allows the viewer to monitor the stern and transom video pictures simultaneously from two different angles.

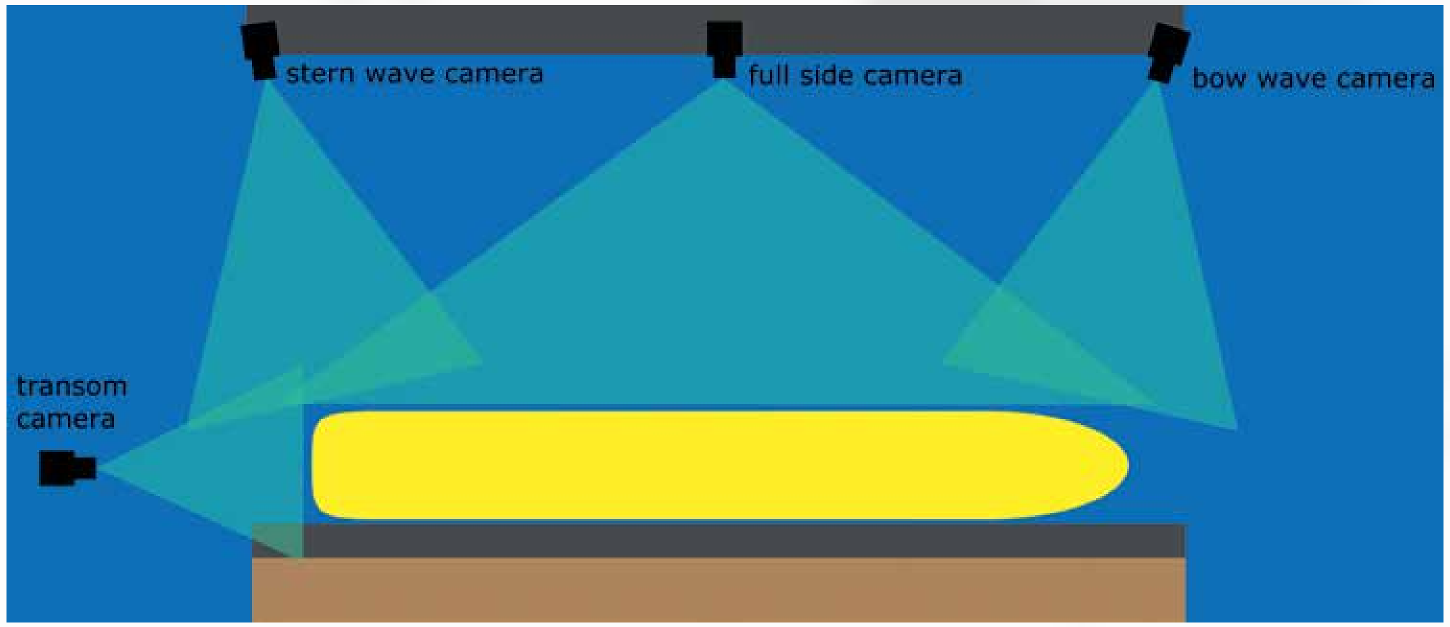


Figure 1: Towing carriage and camera positions

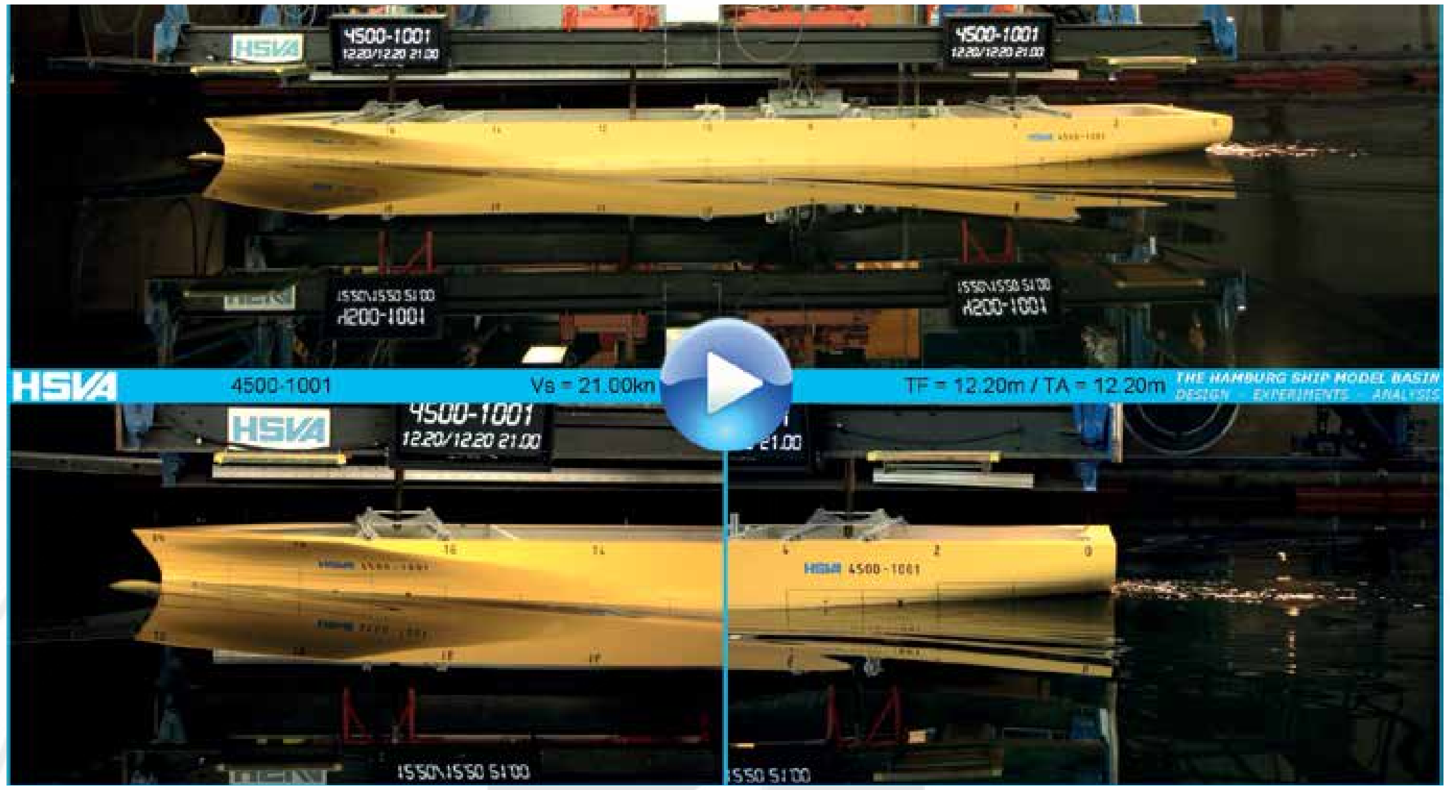


Figure 2: Snap shot of new video layout

But not only the hardware is new! To supply our customer faster with the sometimes badly needed videos, we have built a software (GUI see picture [3]) which is able to automatically process (cutting and assembling) the four video channels. Furthermore it automatically includes some basic test information, so that the viewer always knows exactly the current test condition. The whole system is highly modular and the cameras are capable of shooting 4k, so we can adapt to any future needs if necessary.

In technical matters and for the automation software we cooperated with a subcontractor specialised in customised video installations (**www.kameralabor.de**). ■

Figure 3: Recorder GUI

Figure 4: Transom camera

Figure 5: Stern wave camera

New Head of Arctic Technology Department

Nils Reimer has been appointed new head of Arctic Technology department in February 2017. He will succeed Peter Jochmann, who has been head of the department since 2009 and will retire this April.

Nils Reimer joined HSVA in May 2010 as a project manager in the Ice & Offshore (now Arctic Technology) department. Since then he has been in charge of many model testing projects for various types of ice going ships and offshore structures in ice. Nils Reimer was appointed deputy head of departmend in January 2015. Furthermore he has worked on the development of an ice routing system and wave propagation in ice within research projects.

Nils Reimer studied Naval Architecture and Ocean Engineering at the Hamburg University of Technology in Germany. Within his studies he focused on hydrodynamics and ship structural analysis. In his spare time Nils Reimer mainly enjoys playing with his two young children and outdoor activities like running, hiking and sailing. ■

EMship: A Smart International Master Course as a Win-Win for HSVA and Students

EMship is an Erasmus Mundus master course in integrated advanced ship design including "advanced structure" and CFD education as well as yacht design and production technology (**www.emship.eu**).

Source: Prof. Robert Bronsart, The University of Rostock

Every year a conference brings together the graduated students from all over the world with the new aspirants, the supervising professors and members of an advisory board from the industry offering opportunities for master theses at their companies.

This year the conference was held in the Northern German city Rostock. It was a very well organized meeting displaying the good vibrations of young (in heart) enthusiastic engineers and researchers, offering for all participants a good exchange of ideas and news. The industry partners presented their companies and master topics, and the students presented their master work.

HSVA usually funds several master theses every year among which one or two internships within EMship, addressing the continuous development of the discrete element method (DEM) on breaking ice ridges as presented in this NewsWave issue. This year, Ivan Montenegro being among the best of his cohort gave an excellent presentation of his contribution to the DEM development, and his work was awarded by EMship.

Furthermore, Dr. Janou Hennig was happy to receive an award for HSVA's long-standing support to the EMship programme. Again, EMship proved to create a win-win situation for all, not only by good student contributions to ongoing research work, but also by creating an opportunity to keep in touch with our industry partners and clients and by creating new relations with young, both skilled and passionate professionals. ■