

issue 1-18

HSVA newswave

The Hamburg Ship Model Basin Newsletter



HSVA on Ice

Assistance for Ice Performance Trials

HERM – Harmonic Excited Roll
Motion Tests

HYKAT – Enhanced Procedure
for Propulsion Tests

Constantly Accelerated Resistance
Test (CART) – Seven in One Sweep



Dear reader,

In previous issues of NewsWave, I addressed the importance of close cooperation with our clients and partners from all over the world. We need your input and feedback to continuously improve our services. From your feedback, we identified three major strengths our customers appreciate of HSVA: A strong expertise based in a continuous growth of our knowledge, our long-standing experience, and a thorough quality of our products. As shown in this NewsWave, we have been further working on this!

We base our product palette on three columns – model tests, calculation and design optimization as well as full scale measurements, all services under one roof. In our strategy for the coming years we aim at strengthen in particular the latter two fields. Our first article on impressive ice performance trials is a good example in the field of full scale measurements.

editorial



Regarding the fields of design and optimization of ships, vivid developments are ongoing as the well progressing large EU research cooperation HOLISHIP documents. Extensive CFD studies are also being applied to increase ship efficiency as e.g. the conversion project of RoPax ferry "Peter Pan" shows.

However, we never forget where we come from, and enhancing our model testing expertise will never cease. So we show you in this NewsWave some newly developed experimental techniques for the determination of roll damping, as well as for propulsion and resistance tests. All three will improve our quality and flexibility further, but will also save your and our time and money in the end.

All in all, cooperation remains the key – we need interdisciplinary approaches to imitate nature's best developments for our own designs. In AIRCOAT and Flipper we are working together with partners from industry and research on the reduction of ship resistance by imitating the skin characteristics of sea animals.

We hope to further discuss not only the topics treated in this issue of NewsWave during the upcoming SMM trade fair here in Hamburg. In any case, I am looking forward to meeting you there!

Yours sincerely

Dr. Janou Hennig



HSVA Assistance for Ice Performance Trials

Over the last forty years HSVA has frequently been active assisting clients in ice performance trials for different types of vessels (polar research vessels, multi purpose vessels, supply vessels, LNG tankers). Main objective of these trials is either the acceptance of newly built vessels or research on general ice performance and trafficability aspects.

by N. Reimer, Q. Hisette, C. Schröder

Recently HSVA has participated in another set of ice performance trials contributing with acquisition of onboard data (ship speed, propulsive power) and ice property determination (ice, snow thickness, flexural strength) for analysing the ice performance. Besides the actual task during ice trials HSVA has supported the clients during the planning phase focusing on the selection of suitable testing areas with respect to ice conditions, water depth and accessibility. Furthermore test procedures and logistic tasks have been provided to ensure successful testing under varying circumstances (weather, ice situation) within a limited time period. ▶

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Figure 1: HsVA live screen for monitoring of ship data during each test run

During the ice trial pre-monitoring of ice thickness and ice field conditions is done using satellite imagery, ship borne electromagnetic ice thickness measurements and probe drillings on ice fields. For some of these tasks HSVA is cooperating with geophysics expert teams from other companies. Often suitable testing areas can be found in sheltered waters in which uniform level ice can form and persist for longer time periods. Once a suitable area for testing is found the detailed planning on test conduction including ship's course, weather conditions and available track length is defined.

During each test run (e.g. speed or turning test in ice) all relevant ship data are presented on a live screen (Figure 1) showing the ship's crew and trial team, the development of most important quantities like ship speed, acceleration and propulsion power. The instantaneous values can be used to operate the vessel in an optimal way during the tests and decide whether the time series are suitable for a proper analysis. In a second step suitable track intervals are picked from the time series and ice properties are then determined



Figure 2: Drill hole measurement for ice thickness measurement (above), coring in ice to determine density, temperature, and salinity (right)



Figure 3: Full cantilever beam test for determination of ice flexural strength

using well established methods. Ice and snow thicknesses are obtained from drill holes taken at regular distance along the test track (Figure 2). The flexural strength is determined by temperature, density, and salinity profiles (parameterisation) and validated by in situ full cantilever beam tests which can be carried out in an ice thickness up to 1m (Figure 3).

After all data have been collected the performance analysis is carried out, including correction for environmental conditions (water depth, wind, etc.) deviating from target specified ice conditions. For this purpose HSVA has developed in house routines for processing and analysing the ship motion, propulsion and ice data to obtain the ice performance within very short



time. Intermediate results are prepared as tables and diagrams and are used to develop the final curve of attainable speed in ice.

The team members of HSVA would like to express their gratitude to IMR, NPI, Fincantieri and the crew of RV Kronprins Haakon for the very successful cooperation during the ice trials. ■

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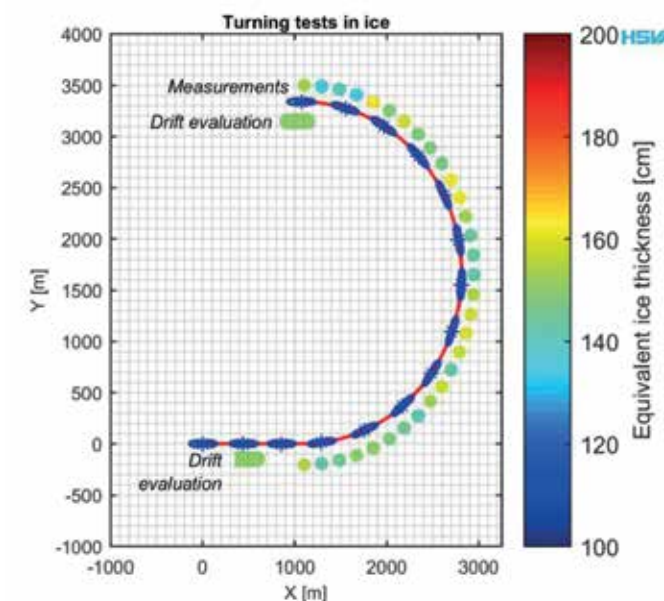


Figure 4: Analysed data of single test run including ice information

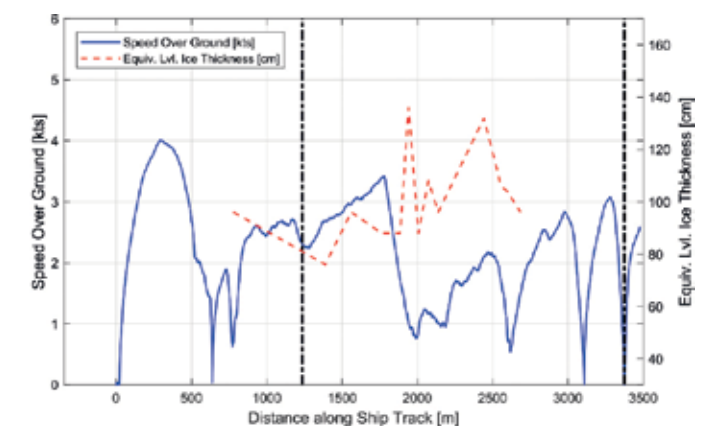




Figure 1: HERM test with a container vessel equipped with FLUME® anti-roll tank

Enhanced Experimental Technique for the Effective Determination of Ship Roll Damping

Roll motions have a clear effect on passenger comfort on board and if excessive they can be a threat to cargo and crew. Beside that they increase ship resistance. Proper dimensioning of anti-roll devices is important. The HSVA has recently developed a new test procedure for the determination of ship roll damping.

by Arndt Schumacher

For the simulation of ship roll motions efficient numerical seakeeping codes based on potential theory has been in use for decades. In general these methods neglect viscous effects and thus the roll damping is underestimated. Accurate roll damping coefficients for the use in these codes can be determined by model tests. Since the mid-70's, the HSVA applies Harmonic Excited Roll Motion (HERM) measurements to determine roll damping coefficients of ships. Compared to the roll decay technique, the

advantage of the HERM technique is the accurate estimation of damping coefficients especially for large roll amplitudes with and without ship forward speed and also in further conditions with high roll damping, when the ship is equipped with roll damping devices like fin stabilisers or an anti-roll tank. Figure 2 shows the roll damping curve of a container vessel with bilge keels at a Froude number of 0.195 ascertained by HERM tests as well as the results of four roll decay tests. The classical roll decay test results show considerably higher scatter than the HERM test results leading to a clear roll damping curve. The HERM repetition tests show very good concordance.

The HSVA previously used an excitation mechanism to perform HERM tests, which was based on the gravity forces of rotating weights. This mechanism and the associated test procedure led to fairly long testing times due to three main shortcomings: (1) The weights, the lever arm lengths, or both have to be manually adjusted or changed to obtain different exciting moments. (2) The excitation moment for a target roll amplitude depends on the unknown roll damping moment. (3) Only after a measured roll transfer function (RAO), one damping value can be manually analysed. Within the frame work of the research project "HERMeS" the HSVA in close coopera-

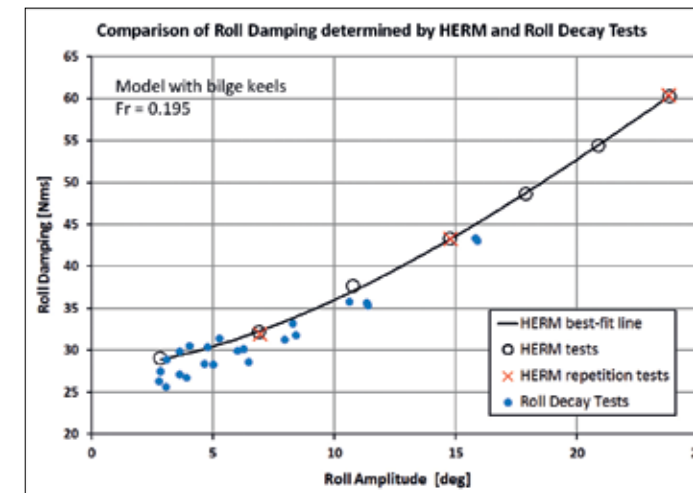


Figure 2: Comparison of roll damping determined by HERM and roll decay tests

tion with the Hamburg University of Technology (TUHH) developed a new HERM test system.

First of all, alternative moment exciting mechanisms for HERM tests based (1) on the inertial effect of a flywheel and (2) on the gyroscopic effect of fast rotating discs were evaluated. The manufacturing effort of a flywheel excitation machine is fairly low, because of its simple mechanism: A fly wheel is directly mounted on the driving shaft of an electric motor (see Figure 3) and the pure excitation moment comes from the angular acceleration or deceleration of the wheel. The major disadvantage of a flywheel machine is its very high electric power and torque demand needed for the sufficient acceleration of the flywheel leading to heavy and large electric motors and frequency converters.

This disadvantage led to the present choice to construct a much more complex, but also more efficient roll excitation machine based on the gyroscopic effect of rotating discs. This concept requires considerably less electric power and

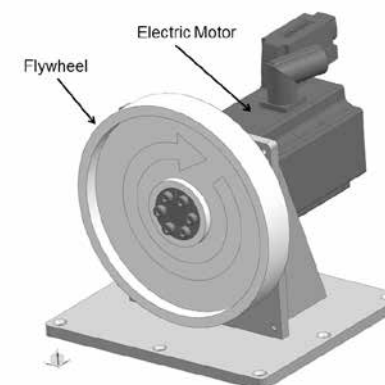


Figure 3: Flywheel concept

enables the generation of higher roll excitation moments, needed to investigate the damping characteristics at higher ship speeds or for ships equipped with anti-roll devices.

The gyroscopic effect is observed when a disc with a mass moment of

inertia J spinning with the angular velocity Ω gets tilted away from its original z -orientation with an angular velocity β around the y -axis (see Figure 4). This forced tilting of the disc applied perpendicular to its rotation axis causes a moment F_E about the axis x , which is perpendicular to both the tilting axis y and the rotation axis z .

The developed gyroscopic excitation machine is shown in Figure 5. The machine consists of two tilting gyros (rotating discs) with the necessary power trains. Each gyro is driven by one small electric motor, and another motor tilts the gyro with a belt drive. In order to generate the desired pure excitation moment around the longitudinal axis of the ship model and to prevent undesired yaw moments the two gyroscopes are accurately controlled so that both their direction of rotation (yellow arrows) and the tilting movement (green arrows) are exactly opposite. The machine is able to generate pure sinusoidal and irregular roll excitation moments for practically all HSVA ship models. Compared to the former excitation mechanism the new excitation machine is more efficient, and the moments are generated "at the push of a button".

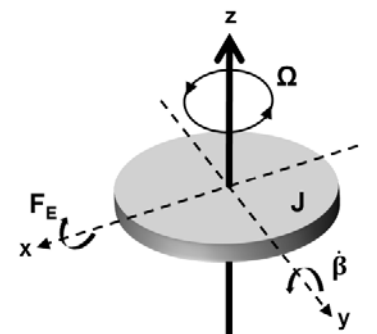


Figure 4: Gyroscopic effect of a rotating disc

In addition to the new roll excitation machine also a new effective test procedure for the determination of roll damping from HERM tests was established. This test procedure consists of three parts: ▶

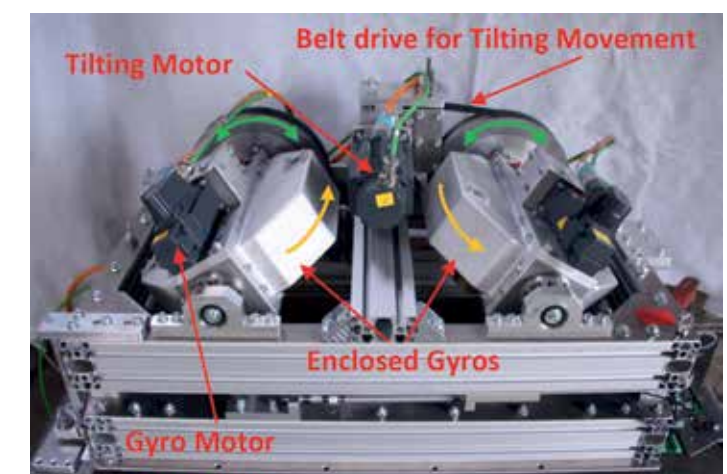


Figure 5: Newly developed gyroscopic excitation machine

1. Before the HERM tests the test setups (mainly model speed and the desired roll amplitude) are defined. For the given setups the excitation moment and period are predicted based on an approximation method developed by TUHH. Thereby, results of already analysed roll motion tests are included.
2. According to the given setups successive HERM tests are automatically performed. The computer controls the roll excitation machine and simultaneously analyses each roll period. A newly developed algorithm (from TUHH) based on Fourier transformation, phase angle determination and area integration methods enables a just-in-time determination of the roll damping at the actual roll period. As soon as the roll damping has reached a stationary state of a required accuracy, the test setup changes automatically. The accuracy control algorithm checks that a stationary state is reached and includes in the calculation values of roll angle, roll period, roll 2. amping, phase angle between roll angle and excitation moment and model speed.
3. The HERM model tests stop with a roll decay test, which is also analysed just-in-time. Figure 6 shows the time history of the roll angle in a typical test run.

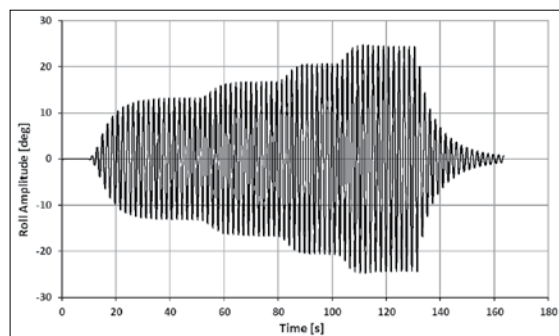


Figure 6: Typical test run – performance of 4 HERM test setups followed by a roll decay test

Due to the just-in-time analysis the roll damping in the tested conditions is directly available after each test run. The results obtained from the HERM and roll decay tests are used to approximate correct setups for further test runs.

Beside the very good repeatability the application of the new HERM test system reduces the required testing time to that of about 25 percent of the previous system. Thus, from now on we can offer our customers to take advantage of a very efficient time and cost saving test system for the accurate determination of ship roll damping. An example of roll damping curves determined for a model of a 326 m long container ship at five speeds is given in Figure 7.

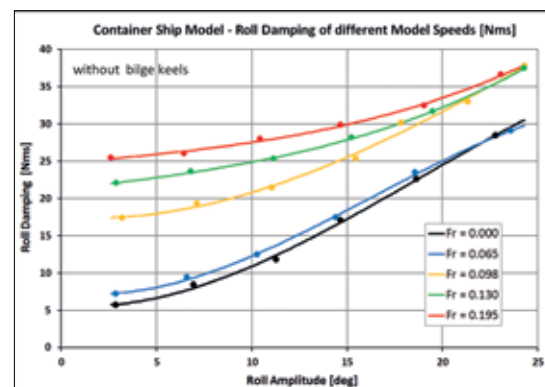


Figure 7: Roll damping as function of roll amplitude

Furthermore, the gyroscopic excitation machine can easily generate irregular roll excitation moments, like the wave excitation moments occurring in natural seas. This enables an accurate and easy comparison of different roll damping device configurations at exactly the same excitation moment values and time histories, as shown in Figure 8. ■

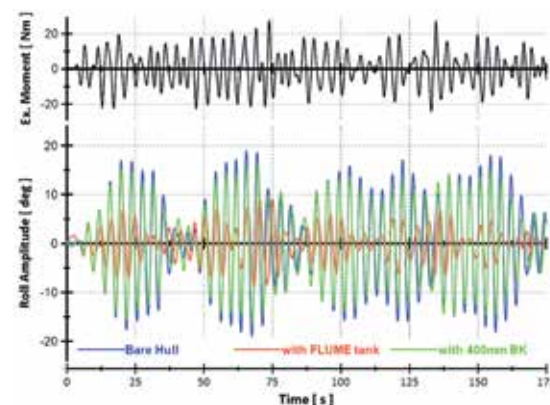
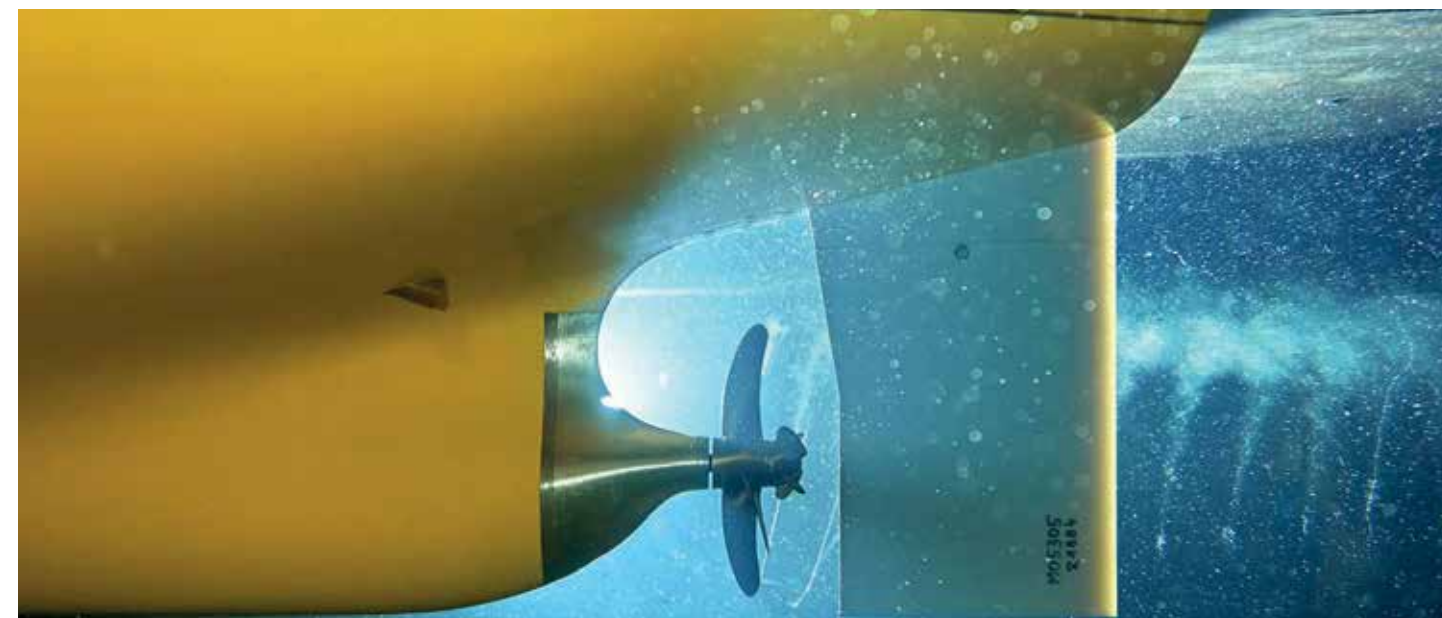


Figure 8: Comparison of the roll motions reached with different roll damping devices (bare hull, with FLUME® anti-roll tank, with 400 mm bilge keels) due to the same irregular excitation roll moment in model scale

The joint research project HERMES is conducted by the Hamburg University of Technology (TUHH), the FLUME® tank designer Hoppe Bordmesstechnik GmbH and HSVA. The shipping company Peter Döhle Schiffahrts-KG is cooperation partner. The financial support of the German Federal Ministry for Economic Affairs and Energy (BMWi) under the project number FZK 03SX413A is gratefully acknowledged. The responsibility for the content lies solely on the author.



Not only for hub caps - the enhanced procedure for propulsion tests in HYKAT



In our NewsWave issue 1/17 interesting news about testing hub caps with fins were presented. In this article a new testing technique to investigate the propulsion improving effect of propeller modifications or propeller cap fins at high Reynolds number and in the wake field of the ship at the same time was explained.

by Julia Schmale

It was explained that the hub caps with fins can hardly be investigated in conventional tests, because of the slow speeds during the propulsion tests and on the other hand the missing wake field in the much faster propeller open water test. In the HYKAT the whole model is installed and can be run with high water speeds. First tests have shown that the effect of a hub cap with fins can be measured with high accuracy during a standard cavitation test with a small extra effort.

Since then, several tests of this kind have been done successfully. The project developed from an in-house research project to a mature customer service. The

Figure 1: NewsWave 01/17

customers show a big interest in these tests, because now a more precise way of predicting the full scale efficiency for efficiency improving devices is available. Several projects have been done so far.

These projects were used to find the best hub cap with fin out of several designs. During these tests some interesting effects of the propulsive behaviour of these hub caps could be seen, underlining the need for this kind of test set-up. All ships and propellers behave differently and not always up to the designers' expectations.

As this test works for all energy saving devices mounted behind the propeller, it is possible to do other interesting tests as well. With the same principle ►



Figure 2: Conventional rudder with load cell in front of the installed rudder during test



not only hub caps with fins can be tested, but also the positive influence of asymmetric rudder profiles, rudder bulbs or fins at the rudder. Therefore the rudder has just to be equipped with a load cell as it can be seen in the picture beside.

The testing is in principal similar to the tests with hub caps with fins, but additionally the rudder resistance is measured. This is done for both the conventionally shaped rudder and the alternative with energy saving features. With the differences in rudder resistances and propeller thrust values obtained at the same HYKAT tunnel water speed, the positive influence of the more efficient rudder can be determined. These tests are now also part of HSVA's portfolio.

were performed with brass and plastic caps to make sure that different surface roughness and stiffness have no significant influence on the results. The tests have shown that no significant influence of different materials can be measured. Even though slight influences can be seen at high loads, the result for realistic K_T values showed hardly any influence.

After two years of intensive in-house research comparative propou- sion tests are now a reliable brick stone in HSVA's portfolio for the investi- gation of energy saving devices. ■

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As often experienced during model manufacturing it can be a challenge to accurately reproduce a full scale geometry in model scale. The challenge with hub cap fins is that the blades can get very thin. Usually such a hub cap is made from rapid prototyping with certain limitations regarding size and thickness of the material. So comparative tests



HOLISHIP News



On 31 May 2018 the HSVA led HOLISHIP project participated in a joint workshop with other EU funded ship design projects SHIPLY and LINCOLN in Brussels. About 60 participants discussed with Commission representatives future trends of ship design and their answers to the evolving requirements.

by Jochen Marzi

On the following day HOLISHIP held its first official Review Meeting after 18 months into the project. Following extensive presentations of the results achieved so far, the project passed the review with excellent marks. The software integration process in HOLISHIP is rapidly pro-

gressing, and the final tool will provide ship designers with a comprehensive and unsurpassed range of design and analysis tools for future challenges. First demonstration cases already now indicate the vast potential of the concept. Providing different CFD tools for hydrodynamic analysis, HSVA is proud that our well known potential flow code **V-SHALLO** has been selected as a first example to demonstrate a new format of software use. System integrators Friendship Systems chose **V-SHALLO** as show case for a first "Web-App" which can be used to optimise the hullform of a given ship. This App is available for testing through the HOLISHIP website at: <http://www.holiship.eu/approach/>

This development gives a flavour of future use of CFD and design software services at HSVA as well as in collaboration with other HOLISHIP partners. ■



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 689074.



The **V-SHALLO** Web-App

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Seven in One Sweep – Constantly Accelerated Resistance Test (CART)

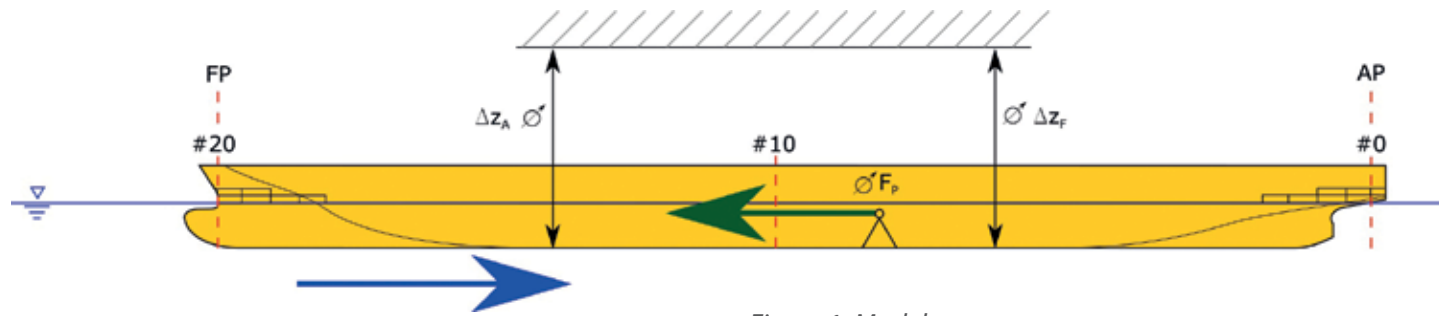


Figure 1: Model test setup

The experimental determination of ship resistance in model tests is usually carried out at pre-selected constant speeds, e.g. seven in total. For each individual speed one sufficiently long test run needs to be performed, costing time and financial effort. The constantly accelerated resistance test is an efficient method to carry out resistance tests in one single test run.

by Jan Lassen and Florian Kluwe

The experimental determination of ship resistance in model tests is usually carried out at pre-selected constant speeds, whereas a common number of speeds is seven in total to achieve a good coverage of the speed range relevant for operation. Test runs are performed with a waiting time in between each run of 20 minutes in order to allow tank water to calm down. So testing 7 runs requires approximately three hours including preparative work.

The constantly accelerated resistance test (CART) requires only one single test run to cover the full speed range. Including validation run and preparative work this means approximately 40 minutes in total which is about 4.5 times faster than the conventional method. Two questions arise: Are the results and the accuracy comparable? And how much accuracy can be sacrificed gaining the tremendous time savings?

During the constantly accelerated resistance test (CART) the towing force and the momentary model speed are measured in the same setup (see Fig. 1) that is used for the conventional test. The test-result is the total model resistance, as well as the trim and heave recorded over the chosen speed range rather than at a single speed only. For this test the model is accelerated at a small, constant acceleration until the chosen maximum speed is reached. From here the model is decelerated in an equivalent manner. Beside the model resistance, the measured tow forces F_T comprise all inertial forces including the hydrodynamic part, i.e. acceleration-dependent hydrodynamic forces (added mass).

For the CAR test, the basic assumption is made that the inertial forces during acceleration and deceleration phase compensate each other. Thus the resistance at a specific speed can be determined from the two resistance values recorded while passing the speed during acceleration and deceleration. This can be done for arbitrary speeds within the covered range resulting in a full resistance curve over the chosen speed range, determined in one single test run.

Fig. 2 shows two snapshots of a resistance test at the speed of 1.5 m/s, where the upper one is from the acceleration phase and the lower one is from the deceleration phase. The waves on the water surface of course differ when looking at the far field, while the deformation along the ship's hull matches perfectly. This indicates a similar pressure distribution on the hull surface.

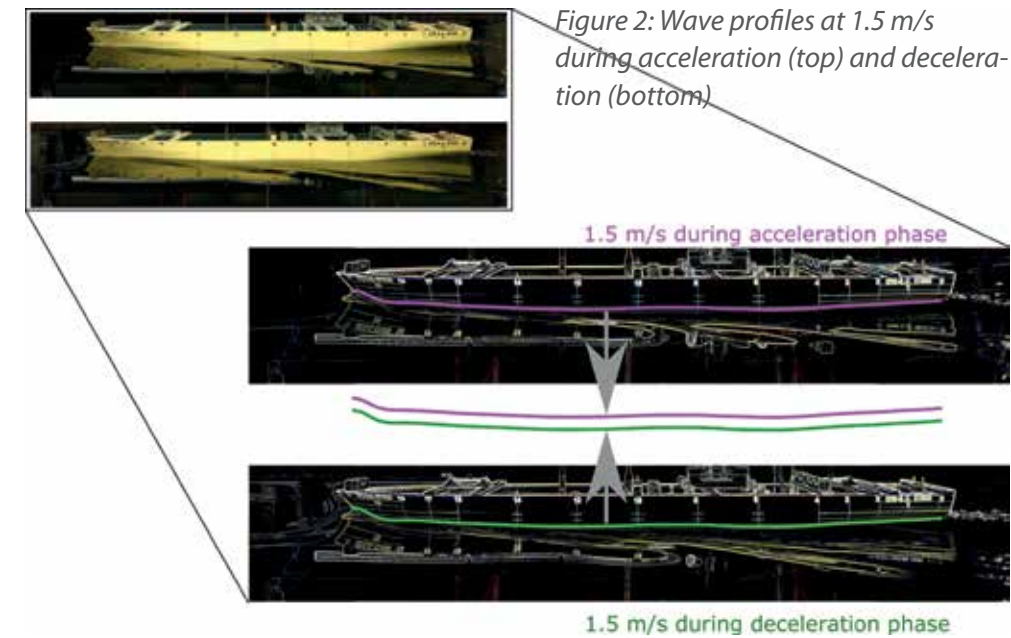


Figure 2: Wave profiles at 1.5 m/s during acceleration (top) and deceleration (bottom)

The results obtained from the reference model show a very good compliance between the conventional resistance test and CART. Meanwhile more than 18 different models were tested in several different setups. 405 single measurements of the conventional total resistance were compared to the one derived from CART. Fig. 4 shows the discrete probability density of the deviation between conventional resistance test and CART, which has an expected value (estimated from the arithmetic mean value) of 0.07 % which is very close to zero. This indicates that obviously

The key concept of the evaluation is the correct mapping of the measured forces in the acceleration as well as in the deceleration phase of the test to the momentary speed. Averaging the two force signals (acceleration and deceleration) results in the resistance value at the momentary speed. The resistance curve is obtained by applying a smoothing spline algorithm via least squares fit.

Fig. 3 shows the direct comparison between CART results and a conventional resistance test at 11 speeds. The tests were performed with HSVA's reference model 4500 on the same day with identical test setup. The deviation, with a root mean square value of 0.6 %, matches the usual repeatability for conventional resistance tests. Using the same model, several additional same-day tests were carried out. It was found that the deviation of the results from both methods was within the one percent range.

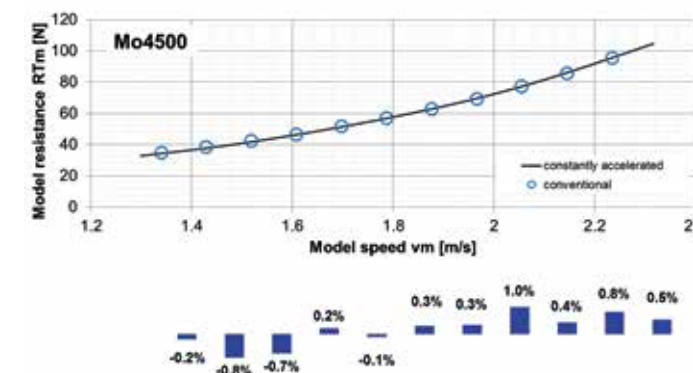


Figure 3: Comparison of CART to conventional resistance method

no systematic error (bias) is present in the test setup and the evaluation-methodology.

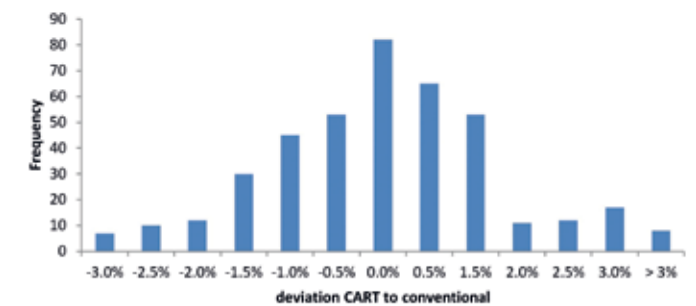


Figure 4: Distribution of discrete deviations of the total resistance for 405 test runs

This demonstrates that seven in one sweep are possible. The constantly accelerated resistance test represents an efficient alternative to the conventional resistance test if certain conditions are met, which are primarily moderate wave making, moderate dynamic trim and sinkage. Acceleration shall be kept as low as possible to limit the influence of possible acceleration-dependent effects apart from the hydrodynamic mass parts that balance against each other. The time savings are best invested into a more detailed assessment of ship's propulsion, e.g. load varied self-propulsion tests. ■

[1] Lassen, J. and Kluwe, F.: "Seven in One Sweep – Constantly Accelerated Resistance Test (CART)", Jahrbuch der Schiffbautechnischen Gesellschaft, 2017

Increasing Efficiency – Conversion of RoPax Ferry “Peter Pan”



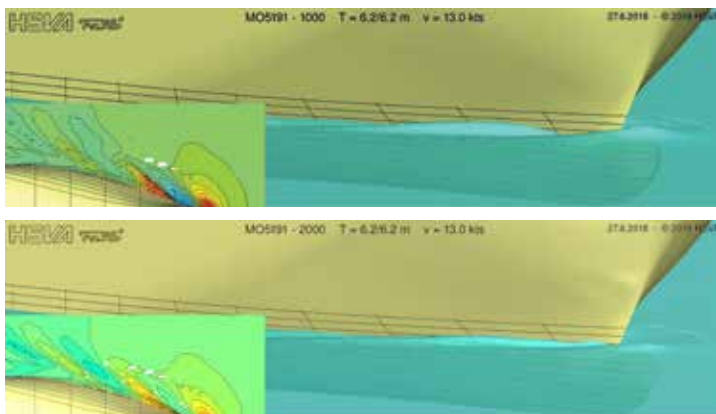
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by Florian Kluwe and Oliver Reinholz

TT-Line has been operating its RoPax ferry duo “Peter Pan” and “Nils Holgersson” on various routes in the Southern Baltic Sea since 2001. Increasing cargo volumes and the aim to decrease costs and environmental footprint of truck and trailer transport aboard of RoPax vessels have driven the decision of TT-Line to lengthen the ferry “Peter Pan”. HSVA has assisted TT-Line with their hydrodynamic expertise, starting from the very early feasibility studies investigating various options of increasing lanemeter-capacity.

HSVA has successfully assisted German ferry company TT-Line in their conversion project of the RoPax ferry “Peter Pan”. HSVA contributed to the project a comprehensive package of analysis and consultancy services including speed-power assessment, hydrodynamic feasibility study, evaluation of hydrodynamic optimisation options by extensive CFD studies and design of a new bulbous bow. Finally all changes and the final speed-power performance of the vessel have been validated by model tests in HSVA’s large towing tank.

Figure 1: Original bulb / optimised bulb



The investigation of the lengthened hull (elongated parallel midbody) revealed that the total increase of required power in average amounted to about 13-15 % relative to the power demand of the original vessel. This resistance increase as typical for such kind of modifications is mainly related to the increase in wetted surface. Further contributing factors are changes in dynamic trim and sinkage as well as changes in wave making resistance. The latter one results from the decreased Froude-number which means that the wave lengths in relation to the ship length become smaller. This potentially has a decreasing effect on the wave making resistance. Further, changes in wave interference have to be considered as the hull-elongation by adding a parallel midbody changes the interference patterns of the waves.



Although the increase in total power demand is significantly overcompensated by the increase in cargo capacity when it comes to fuel consumption per transport unit, HSVA was asked to investigate measures to limit this increase.

The investigation comprised modifications of the bulb as well as modifications to the stern. The idea of stern modifications is twofold in this respect: Firstly a direct influence is expected by a reduction of the transverse stern wave system. Secondly such changes can positively influence the dynamic trim of the vessel. Technically this is done by adapting the slope of the buttocks at the stern, changing transom immersion, flow speed and direction. This is often connected to local lengthening of the waterplane area by adding a duck tail. In the present case the modifications within the possible solution space did not show savings large enough to justify an investment into conversion. This is also founded by the dominance of low ship speed in the desired operating profile.

A much larger potential for power savings was found in the bulbous bow of the vessel. The original bulb was designed in course of a traditional “single-point” optimisation showing its best performance in the vicinity of the contractual design condition at 22 kn. As mentioned above the real operating profile of “Peter Pan” nowadays is dominated by lower speeds. This results in the typical, very steep wave trough behind the high volume bulb along the narrowing waterlines. This generates a very steep, breaking wave. Moreover, such kind of high volume bulbs have a large cross sectional area causing significant resistance. This type of bulb is also known for having adverse effects for the vessel’s added resistance in short waves.

The design task here was to generate a new bulb shape that overcomes the drawbacks of the original design while maintaining the ability to generate low pressure flow in front of the ship’s stem aiming to achieve the desired bow wave reducing effect. HSVA has investigated 5 mature design-alternatives in depth by means of CFD (RANS) calculations, demonstrating the ability to reduce power consumption at the dominating operational speeds by up to about 13 %. Typical



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Figure 3: Fitting the optimised bulb to the bow of “Peter Pan”

for such type of modification is that savings at lower speeds always generate some penalty at larger speeds. A good design aims to balance these effects, providing a good overall performance on various operating conditions. The final design variant achieves this goal by providing significant savings on the low speed side while at the same time not generating extra power demand at higher speeds.

Two model test campaigns have verified the findings of the numerical study, confirming the significant savings. Consequently TT-Line has decided to realise not only the lengthening project but also to fit a new modified bulb to the bow of “Peter Pan”. This significantly reduces the extra power-demand originating from the lengthening of the ferry. ■

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Scope of services carried out by HSVA

- feasibility study, speed-power prediction
- development and optimisation of hull lines modifications: bulb, trim wedge, ducktail
- extensive viscous flow CFD calculations
- resistance and propulsion model tests for original vessel, lengthened vessel, hull form modifications
- performance prediction of final variant including capability check of electrical drives
- assessment of modification with regard to hydrostatics and loading conditions by SDC Ship Design & Consult



FLIPPER in the water tunnel

Modern methods and tools have pushed wave-resistance optimisation to levels that leave little potential for further significant improvement. The focus has therefore shifted towards reducing the skin-friction drag of ship-hull surfaces.

by Lars-Uwe Schrader

HSVA undertook numerous projects in the past dealing with drag-reducing hull coatings – mostly in turbulent boundary layers. In contrast, the research project FLIPPER was focused on laminar and transitional boundary-layer flow along the bow section of a small SAR ship with the aim to develop a coating for delay of transition to turbulence. The soft skin of

dolphins served as a natural example of such a compliant coating for transition control. The present article is the last of a trilogy (see HSVA Newswave issues 2015/1 and 2016/1), focussing on the numerical estimation of drag reduction and the final experimental investigations in the project.

Estimate of drag reduction

Numerical methods such as 3D flow simulation, boundary-layer calculations, linear stability analysis for transition prediction and a mechanical model of (artificial) dolphin skin were used to estimate the location of laminar-turbulent transition in flow over a rigid and two compliant surfaces [1]. The compliant coatings under investigation were made of a 1:1 blend of two silicone gels with different viscoelasticity, considering two coating thicknesses: 3 mm (coating 1) and 9 mm (coating 2). According to the calculations, these coatings were able to delay the transition to turbulence by nearly 29 cm and 90 cm compared to the rigid surface. The drag reduction at the bow of the SAR ship model (5.72 m length) could then be calculated based on the computed laminar and turbulent skin-friction lines and the change in area wetted by laminar flow (Figure 1). This exercise yielded a frictional drag reduction of 1.7% for the thinner and 5.6% for the thicker compliant coating with respect to the rigid surface (Table 1).

	Coating 1	Coating 2
ΔA_{lam} [m ²]	0.14	0.42
ΔF_r [N]	-17.4	-55.7
$\Delta F_r/R_r$ [%]	-1.7	-5.6

Table 1: Change of friction (ΔF_r) for the compliant coatings 1 and 2 compared to the rigid surface; absolute value and relative change with respect to the frictional resistance R_r of the ship model

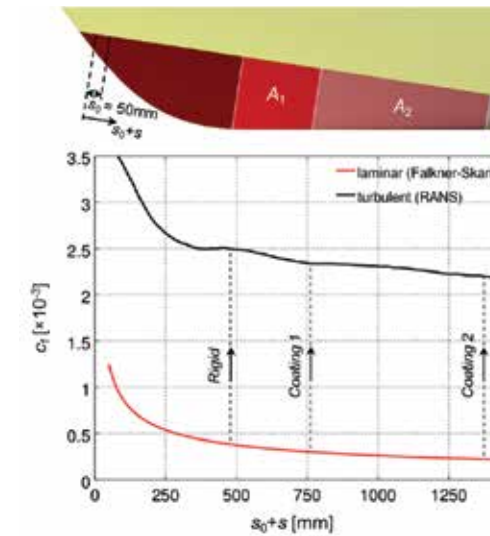


Figure 1: Skin-friction drag at the bow of a SAR vessel in scale 1:3.2 for a rigid surface and two compliant coatings. Change in area of "laminar wetting" at the bow for estimation of drag reduction (cf. Table 1)

Water-tunnel tests

A wooden 1:3.2 scale model of the SAR vessel with a removable bow, connected to the hull via a load cell, was manufactured and inserted into the HYKAT water-tunnel test section (see thematic picture of this text). The compliant coatings (Figure 2) were fabricated and attached to the bow segments by HSVA's partner Fraunhofer IFAM, a specialist in paints and coatings.

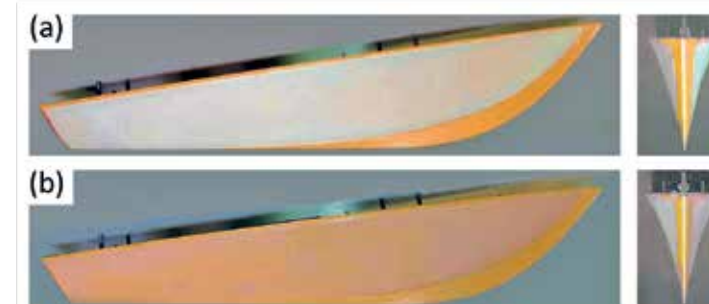


Figure 2: Bow segments with compliant coatings of (a) 3 mm and (b) 9 mm thickness made of a 1:1 blend of two silicone gels with different stiffness and damping and a polyethylene film on top

The HYKAT was operated at speeds between 2 m/s and 10 m/s. Below 3 m/s, the flow was entirely laminar along all bows such that the transition-delaying capability of the coatings was not yet at play. Beyond that speed, the coatings – especially the thicker one

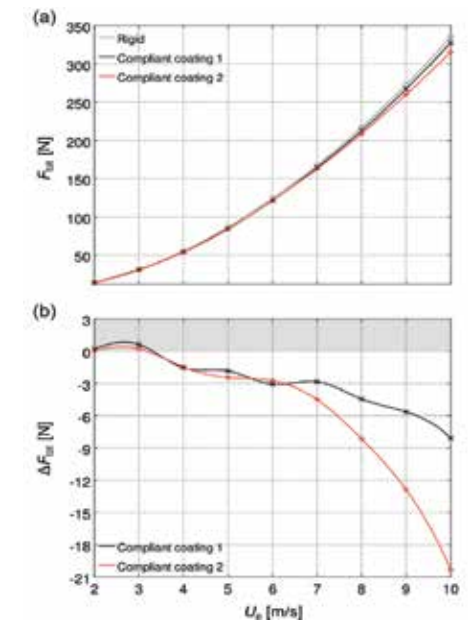


Figure 3: Drag force on a rigid and two coated bow segments at different tunnel speeds: (a) Load-cell data, (b) measured force difference between the compliant surfaces and the rigid (painted) reference

– became more and more beneficial, yielding a drag reduction by over 20 N at the highest speed.

Summary

In the project FLIPPER, HSVA and partners were able to demonstrate the functionality of "artificial dolphin skins" for frictional drag reduction. The measured drag diminution was lower than the computational prediction owing to simplifications in the numerical approach while the predicted trends were all confirmed in the tests [1]; the calculations also pointed to further potential for coating optimisation. A basis for maritime applications is laid, but aspects such as ruggedness and anti-fouling of the coatings need to be addressed prior to a practical implementation. ■

The project FLIPPER was funded by the Federal Ministry for Economic Affairs and Energy of Germany.

[1] Schrader, L-U, Passive Drag Reduction via Bionic Hull Coatings, Procs. 32nd Symp. Naval Hydrodyn., 2018 (accepted)

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Figure 1: The AIRCOAT foil

The Horizon 2020 AIRCOAT project: A Biomimetic Hull Coating to revolutionise the ship coating sector?

The European Commission granted an innovative project intending to develop a biomimetic hull coating that reduces the frictional resistance of ships. The AIRCOAT project promotes a ground-breaking technology that has a high potential to revolutionise the ship coating sector and to be a game-changer for reducing energy consumption and emissions of Europe's waterborne transport. A team of ten European scientists and industry experts led by the Fraunhofer Center for Maritime Technologies and Services will receive a total grant of 5.3 million Euro to develop and demonstrate the AIRCOAT prototype.

by Herbert Bretschneider

AIRCOAT (Air Induced friction Reducing ship COATing) develops a passive air lubrication technology that utilises the biomimetic Salvinia effect. This effect enables trapping air while submerged in water. The project technologically implements this effect on a self-adhesive foil system (Figure 1). Applying a ship with such an AIRCOAT foil will produce a thin permanent air layer, which reduces the overall frictional resistance significantly while acting as a physical barrier between water and hull surface. Therefore, besides substantially reducing main engine fuel oil consumption and hence exhaust gas emission, the air barrier further inhibits the attachment of fouling and the release of biocide substances (of underlying coatings) to the water and mitigates the radiation of ship noise. ▶

The three-year project started on May 1st 2018 and receives a total grant of 5.3 million Euro from the European Commission within the Horizon 2020 framework addressing the topic innovations for energy efficiency and emission control in waterborne transport. Besides the Fraunhofer Center for Maritime Logistics and Services (CML), the interdisciplinary project consortium includes the German partners Karlsruhe Institute of Technology (KIT), the City University of Applied Sciences Bremen and the Hamburg Ship Model Basin (HSVA). It further includes Avery Dennison Materials Belgium, PPG Coatings Europe BV from the Netherlands, Danaos Shipping from Cyprus, the AquaBio-Tech group from Malta, the Finnish Meteorological Institute and Revolve Water from Belgium.

The project is a prime example for a biomimetic application where technology is learning from nature. Nature has developed the Salvinia effect, which allows the Salvinia plant (Figure 2), a fern floating on the water, to breathe also under water by keeping a permanent layer of air. Now, technology makes use of this natural phenomenon. The Salvinia effect was described and elucidated within the BMBF ARES project of the Universities of Karlsruhe (KIT), Bonn and Rostock and a project at the KIT funded by the Baden-Württemberg Foundation. These projects already demonstrated the feasibility of air coating under water and its potential for technological applications. One of the pioneers of aircoating, the nanotechnology expert Professor Thomas Schimmel from the KIT, who is the scientific coordinator of the AIRCOAT consortium, comments:

"After understanding the Salvinia effect we challenged ourselves and came up with a methodology to produce an artificial surface that imitates the Salvinia effect in the laboratory. Every day, when entering my lab, I am again amazed to see that an early prototype, which we put under water more than 5 years ago, is still covered with a permanent air layer – keeping dry under water for more than 5 years!"

Professor Schimmel soon realised the large potential of this invention for the shipping industry. He joined forces with the Fraunhofer CML and they together conceptualised the AIRCOAT project to bring the prototype to the next level and to show its industrial viability. They therefore formed a consortium consisting of leading scientists from applied physics and nanotechnology, from experimental and numerical fluid dynamics, biomimetics, innovative ship technology and ship emission modelling together with industry experts from marine coating, ecotoxicology, self-adhesive foil and container ship owner.

The consortium develops small-scale prototypes to optimise the surface characteristics of this new technology supported by experimental and numerical methods. They further produce large-scale pilots to demonstrate the efficiency and industrial feasibility in operational environments (laboratory, research ships, and container ship). Finally, they will perform a full-scale validation process to investigate and demonstrate the economic and environmental benefit. AIRCOAT Project Coordinator Johannes Oeffner from the Fraunhofer CML comments:

"The potentials of AIRCOAT are enormous. Initial estimates show that the AIRCOAT technology can reduce at least 25% of main engine fuel oil consumption and hence 25% of exhaust gas emission."

Major advantages to existing technologies are that the ship hull is passively lubricated.



Figure 2: Salvinia molesta floating leaf



Figure 3: Coated UW body for friction test at high speeds

ted and that the refit technology would be immediately applicable to the whole fleet. Through combination with latest self-adhesive foil technology AIRCOAT can revolutionise the maritime coating sector and become a ground-breaking future energy efficiency and emission reduction technology.

Within AIRCOAT HSVA receives a funding of 655 thousand Euro. HSVA will support the project by its expertise in hydrodynamics and related testing to bridge the gap between fundamental research and industry to ensure the holistic AIRCOAT approach. HSVA will contribute to optimising the AIRCOAT surface structure via experimental hydrodynamic testing from small-scale prototype to near-operational Reynolds numbers of boats and ships (Figure 3). Further HSVA is involved in the development of appropriate scaling procedures to real ships and of a method to quantify and monitor the actual air layer.

During the SMM – the leading international maritime trade fair in Hamburg – on 6th of September 2018 the AIRCOAT

concept and an expected outlook will be presented in a Stakeholder Event in room B6.5 in Hall B6. We are looking forward to welcome you and to discuss your questions! ■



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 764553.

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We look forward to seeing you at our stand B4.EG108 at SMM 2018.

4 - 7 sept 2018
tue - thu 9.30am - 6pm
fri 9.30am - 4pm

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The TrAM H2020 project (2018-2022)

TrAM: Transport: Advanced and Modular



The new European Union TrAM-project (2018-2022) is dealing with the design and construction of zero emission, battery driven fast vessels for coastal/river/inland waters transport services as "Urban Water Shuttles". It was awarded 12M Euros funding from the EU's Horizon 2020 research programme.

by Apostolos Papanikolaou

The project is coordinated by the county of Rogaland in Stavanger and NEC Maritime CleanTech. It is expected that this project will further enhance the know-how of building zero emission vessels in Norway and set technological and environmental impact standards for environmental friendly, worldwide waterborne urban transports. In TrAM HSVA be in charge of the numerical optimisation of vessels' hull form and propulsion system, as well as the verification of the results of the demonstrator design by model experiments. Project partners are besides Rogaland County and NEC, the Norwegian cluster partners Hydro Extrusion, Leirvik and Fjellstrand shipyard, while from European side besides HSVA the following participants: Wärtsilä Holland (Netherlands), MBNA Thames Clippers (UK), University of Strathclyde (UK), Fraunhofer IEM (Germany), National Technical University of Athens (Greece) and Waterwegen & Zeekanal NV (Belgium).

The project's main objective is to develop and validate

by the testing of a built full scale demonstrator a new concept for waterborne modular design and construction with focus on electrical/battery powered vessel operations in protected waters, coastal areas and inland waterways. The project will result in a new battery driven, high-speed catamaran vessel with zero emissions that will operate between Stavanger and Hommersåk at the west coast of Norway. It is noted that until now, battery driven prototype vessels are operating at lower speeds. In addition, new manufacturing/modular methods, known from the automotive and aircraft industry, will be implemented that are expected to contribute to significant lower production and engineering costs. Finally, most recent developments in light weight/high capacity/fast recharging battery technologies will be exploited. The construction of the demonstrator vessel by the well established Norwegian shipyard Fjellstrand will be co-financed by Rogaland County (end user). The project will also conduct two additional studies for the same type of vessel for shuttle operations on the Thames River in London and river cargo transports in Belgium to explore opportunities for similar zero emission vessels on selected routes in Europe (and ultimately worldwide). ■



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 769303.

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Double-ended Ferries: Special Design Challenges and Solutions

Turning manoeuvres cost time and fuel, an important aspect especially on short sea routes across rivers, fjords or between islands. The time loss must either be compensated by higher travel speed or avoided in the first place to achieve the required turnaround times. That's why we see so many double-ended ferries operating those routes.

by Jörg Brunswig / Peter Horn

The design of double-ended ferries involves special challenges. Different from conventional ships, forward and aft shoulders cannot be placed independently due to the symmetry with respect to the midship section. The longitudinal location of the centre of buoyancy is fixed and the hull lines design requires a symmetric section area curve for the same reason. Furthermore the vessels usually have low block coefficients and small midship coefficients. The requirement of loading capability towards both ends of the vessel drives another special characteristic: wide deck lines and extreme bow flare. The arrangement of the bilge keels is a much more difficult task because the best compromise for both directions of travel must be identified.

"...connected to innovative energy concepts like the usage of LNG or batteries as propulsion power supply."

Additional challenges involve the propulsion concept as the ferries typically have propulsion units at both ends of the vessel. Special attention is required regarding the choice of the propulsion system (e.g. fixed shaft with rudders or POD units) and the arran-

gement of the propulsors (symmetrical or asymmetrical with respect to CL). The load distribution between aft and forward propulsion units is also a very important issue to be considered. These hydrodynamic challenges are nowadays mostly connected to innovative energy concepts like the usage of LNG or batteries as propulsion power supply.

"State-of-the-art CFD tools and long lasting experience are the key for leading double ended ferry design"

When dealing with these special aspects of double-ended vessels, customers can benefit from HSVA's long term experience gained during numerous model tests and design projects over the last decades. Diagram Figure 1 shows an extract from our database and Figure 2 shows a typical situation in our large towing tank. HSVA provides first class consulting using state-of-the-art CFD tools to support shipyards and operators with their double ended ferry designs.

As a quite successful example for such a cooperation, we have been working together with one of our long term partners, Multi Maritime AS, a major player within the

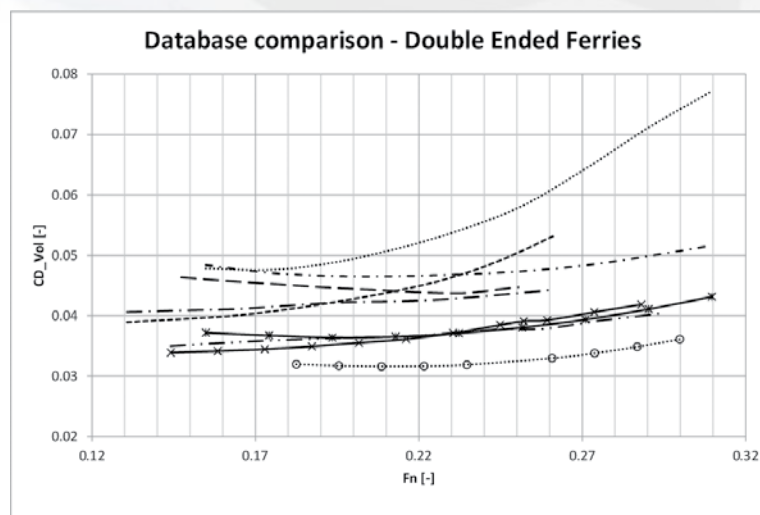


Figure 2: A database comparison of some of the normalised speed-power curves of HSVA's model test database



Figure 3: Bow wave of a double ended ferry in the towing tank

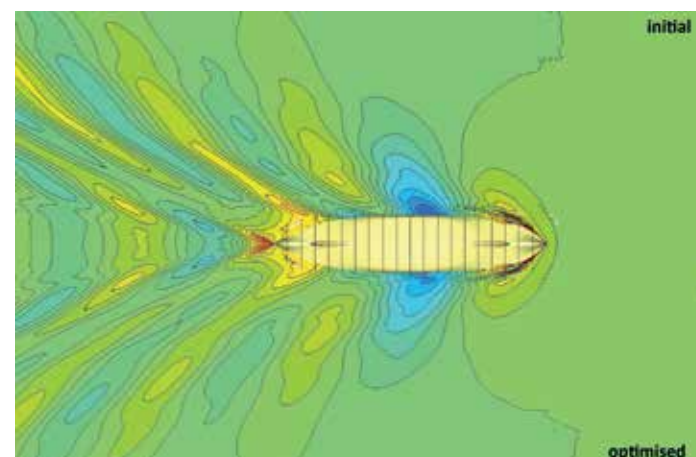


Figure 4: Results of hull form optimisation

development of "green" double ended ferry technology (see Figure 1) with special focus on energy efficiency and zero- / low emission concepts. About 35 electric or battery hybrid ferries of Multi Maritime design have already been contracted so far. HSVA assisted Multi Maritime with

hull design expertise (see Figure 4), detailed CFD analyses and highly sophisticated power prediction services during the design stage. During the hull form optimisation the resistance was reduced by 20% induced by a pronounced bow wave at higher speeds. Another 10% savings were achieved over the complete speed range by other hull form modifications.

"Sometimes environmental factors impose additional challenges."

Double-ended ferries often operate in shallow water and harbours with very limited space, requiring excellent manoeuvring capabilities. Sometimes environmental factors impose additional challenges. A good example is a project HSVA carried out for our customer Navis Consult d.o.o (design company part of Rolls-Royce Marine AS) for an 80m-double-ended ferry for short distance operation between the Croatian island Rab and the mainland (ship owner Rapska plovidba). The region is known for its katabatic winds called Bora, which often occur quite unexpectedly and suddenly and involve extremely high – sometimes hurricane force – wind speeds. Short and steep seaway builds up quickly, making safe operation of the vessel more difficult. The customer's prime concern was that the ferry would not be able to maintain manoeuvrability in these conditions. An additional challenge was the fact that the four ducted thrusters would have to operate near the waterline due to draught limitations, leading to a significant risk of propeller ventilation and associated thrust reduction. ▶

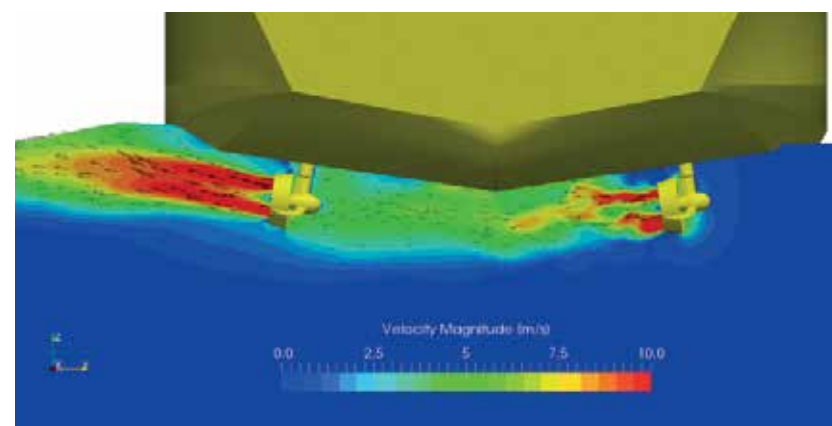


Figure 5: Transverse thrust simulation

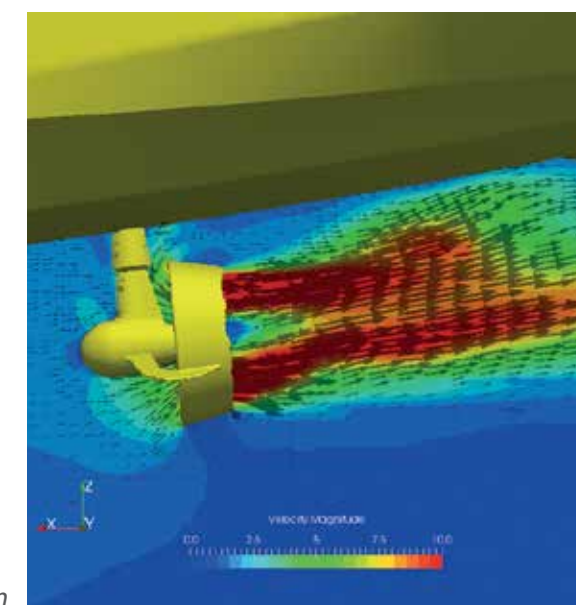


Figure 6: Stern thruster in bollard pull condition

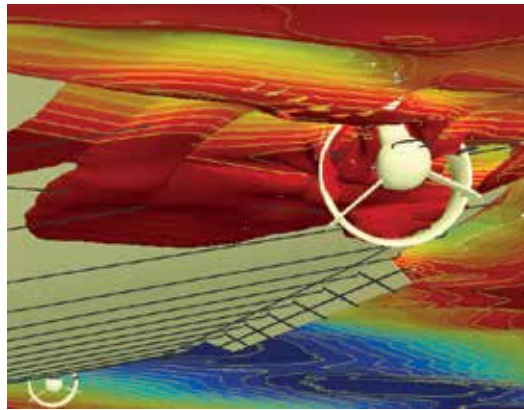
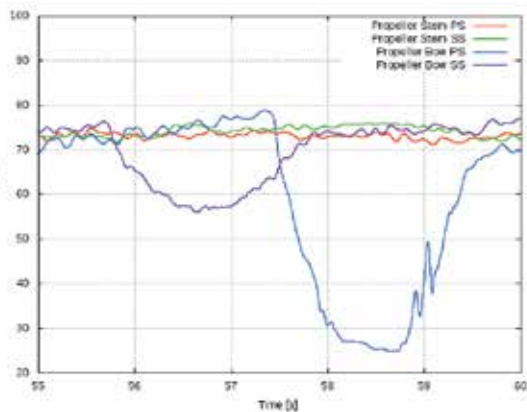


Figure 7: Thrust during one encounter period

Figure 8: Ventilating propeller in seaway

HSVA carried out a number of high-fidelity simulations using our in-house viscous CFD code **FreSCo⁺** to assess the risks and identify possible design changes to improve the vessel's behaviour in severe conditions. A sea keeping analysis was performed to determine the ship motions and slamming risk. For the thrust predictions all four ducts were modelled in great detail (Figure 5 and 6), the propellers were replaced by an actuator disk using body forces linked to the propeller's open water diagram. The numerical model was adapted to correctly handle propeller ventilation phenomena. The outcome of the study was that no ventilation-induced thrust reductions are to be expected in calm water. When operating in a short seaway of 1m significant wave height, propeller ventilation occurs to an extent leaving the vessel fully operational, see Figure 7 and 8. Based on this knowledge, the customer made sure that the engines would be able to handle sudden load vari-

ations. The vessel is now in service and the owner gave feedback to Navis Consult that the vessel's operation is fully satisfactory in all conditions.

We at HSVA are looking forward to all future double-ended vessel projects, no matter what the challenges are! ■

HSVA Services for Special Purpose Vessels

- Speed-power predictions
- Hull form design
- Hydrodynamic consultancy
- CFD resistance calculation
- Propulsion concept analyses
- CFD propulsion analyses
- Seakeeping analyses
- Assessment of slamming risk
- Manoeuvrability analysis
- Model tests
- Speed-power prediction in brash ice

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Member of staff Daniela Myland

Daniela Myland has held the position of the deputy head of department Arctic Technology since April 2017

Daniela Myland joined HSVA in July 2011 as a project manager in the department Ice & Offshore (now Arctic Technology). Since then she has been in charge of many ice related model test projects for various types of ships and offshore structures. Moreover she takes care of the coordination and technical work of research projects dealing with ship-ice and propeller-ice interaction.



Daniela Myland studied Naval Architecture and Ocean Engineering at the University of Duisburg-Essen in Germany. Within her studies she mainly focused on ship hydrodynamics. In her spare time she enjoys to spend time with her family, preferably during outdoor activities. ■