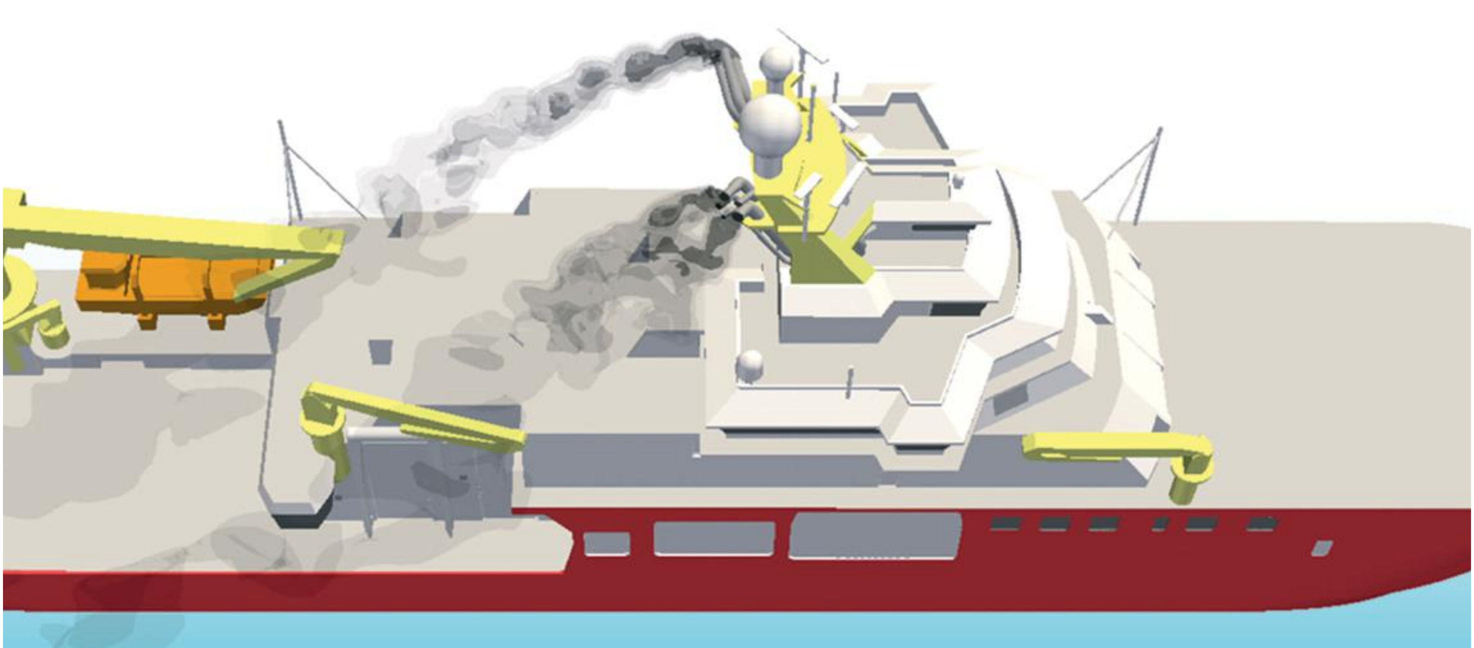
MARINTEC CHINA 2017 SPECIAL

issue 2-17

newswave

The Hamburg Ship Model Basin Newsletter



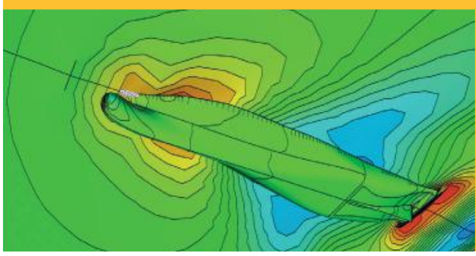
Smoke on the Water

Simulation of exhaust dispersion and other aerodynamic aspects of ships in HSVA's virtual wind tunnel

Full Speed Ahead with HOLISHIP – A European Success Story

Model Manufacture – Dedicated Precision Makers at Work

Propeller-Ice Interaction as a Design Aspect of Cargo Ships



editorial

Dear reader,

this issue of our Newswave is in particular dedicated to the MARINTEC trade fair which is a good opportunity for HSVA to meet old and new colleagues, partners and friends from all over the world to exchange the latest business news and developments in the maritime market. Our expectation is that we will be able to further strengthen our cooperation during this important event, and therefore MARINTEC in the impressive and ever changing city of Shanghai is a fix point in our agenda.

Cooperation is the core of our business, and we are very proud to have included the viewpoints of our long-term partners MARIC and SDARI, represented by President Xing Wenhua and President Hu Jin-tao, in our MARINTEC special. China's cruise market is strongly growing, and we are gladly serving as a reliable partner in the major hydrodynamic and polar aspects and solutions. As the market is demanding for more and more various and special approaches herein, we share with our customers the challenge to tailor our services and products not only to their individual specifications, but also during a continually decreasing time window and at excellent accuracy and quality. So our first article gives insights into our model manufacturing and the latest developments in the related quality checks.

We face an increasing demand for more complex model tests, and the entire "seakeeping package" is a good example for this. As can be read in the following, we help to make ships being able to safely return to port! In the cruise and yacht business, the flow of smoke is a major issue, and we are happy to be able to give reliable predictions and advice by advanced CFD methods – and all at full scale!

Recently, we had the pleasure to discuss our approach in the ProEis project towards workability due to propeller-ice interaction during a dedicated workshop in Hamburg. The participants shared their views on possible challenges and applications. These inspiring contributions from our partners and clients were another good example for the benefit of cooperation.

We at HSVA thank you very much for your interest and continuous support! I wish you a good business and fruitful discussions at MARINTEC!

Yours sincerely

Dr. Janou Hennig

Impressum / imprint

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

Konzept / Concept
Chrisandi Communications
Auf dem Sande 1
D-20457 Hamburg
Tel. +49-40-369 84 215
Fax: +49-40-369 84 299
kontakt@chrisandi.de
www.chrisandi.de

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

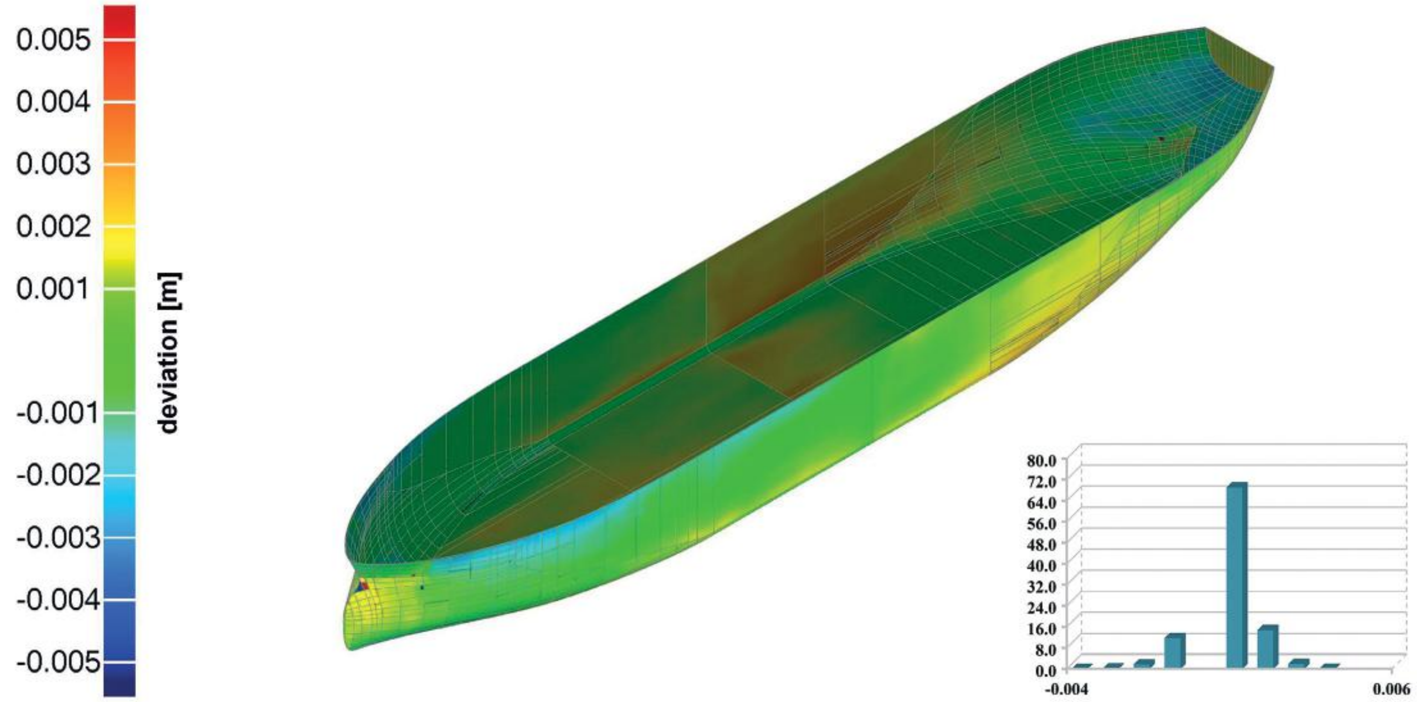


Figure 1: Geometry check of a four year old wooden hull

Precision in Model Manufacture

From the very beginning in the year 1913 the quality of the model hulls, propellers and appendages, which are used for the tests in the various facilities, has been the basis for reliable and accurate measurements at HSVA.

by Hilmar Klug

Driven by the market and legal changes modern ship designs feature various energy saving devices reducing the power consumption by a few percent. The validation and optimisation of the devices and designs require a high quality of the models and experiments, and HSVA continuously investigates and refines the quality assurance procedures.

Reliable and repeatable test results throughout the whole test campaign, which sometimes stretches across years, require models of high geometrical accuracy and long-time stability. Therefore HSVA uses a constant quality assurance process in all the model workshops.

In the past geometry checks have been performed manually, supported by in-house-developed tools. But since the modern fabrication chain is fully covered by computer aided design and manufacturing tools, also the quality assurance nowadays is based on computer aided tools.

Ship hulls

Ship hulls are manufactured at HSVA typically from wood. The raw block is manufactured from some ten layers, following the outer shape of the hull. This reduces the amount of material used and the time required to shape the hull with the computer controlled milling machine. The check of the correct alignment of the raw block on the milling bed and the calibration ▶

of the milling head prior to starting the milling process are mandatory. After milling the hull the final surface smoothening is done manually by the experienced craftsmen in HSVA's model work shop. Painting the model and applying the photo grid and draft marks finalise the fabrication of the hull model.

Three quality gates have to be passed by the hull during manufacture. The first check is done directly after milling the raw block. The second is performed before the model is prepared for the first model test. The last check is done every time the model has been prepared for a test and fitted with the required components and sensors.

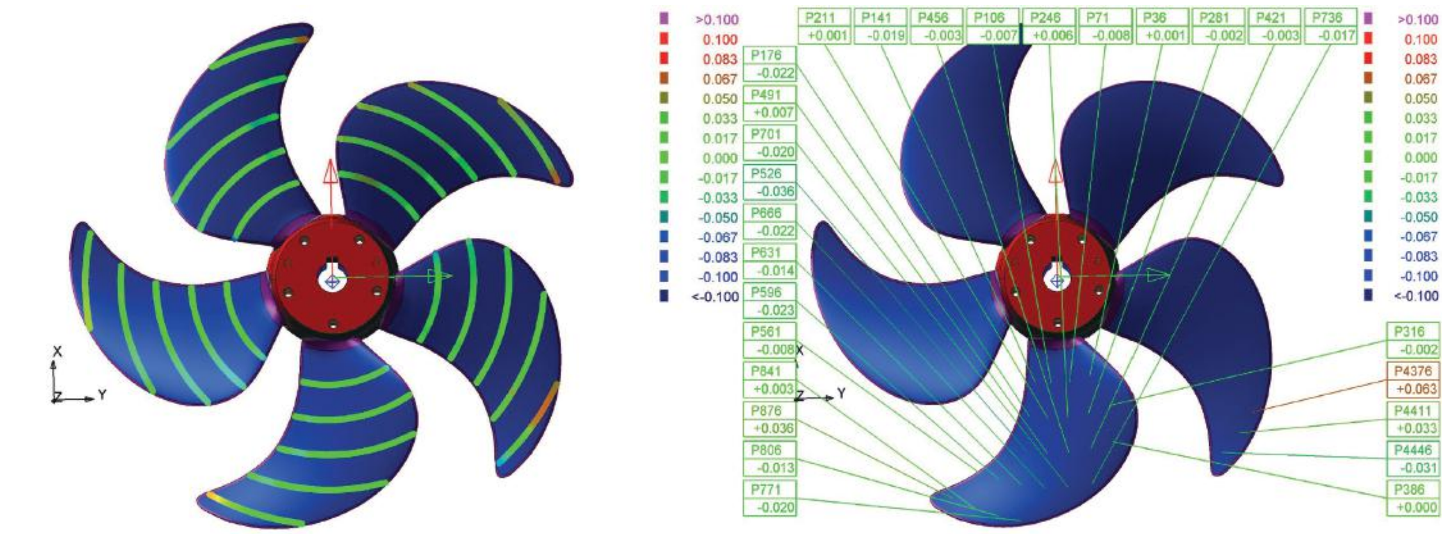


Figure 2: Geometry check of a model propeller

About twice a year a number of randomly chosen hulls are 3D scanned by a sub-contractor covering the entire hull topology. The differences between the actual and the target geometry are analysed, and corrections to the manufacturing process are made if needed. Several different scanning methods have been tested and evaluated. Among them have been optical systems, laser scanners and mechanical devices. The most accurate and reliable results have been achieved with an ultra-mobile laser scanner (Creaform HandySCAN). For ship models longer than eight meters the system is combined with a second laser scanner (Leica ScanStation).

Appendages

Appendages and hull details like rudders, fin stabilisers, brackets and thruster screen grids are either produced using HSVA's own 3D printer or are made from brass in the five-axis milling machines of the mechanical workshop. The 3D printer is also used for manufacturing covers for fin stabiliser pockets, energy saving devices like rudder bulbs, pre-swirl stators and wake equalising ducts.

Propellers

Propellers are typically made from brass using a five-axis milling machine. The final geometry check is performed with an automated high precision measuring device (Zeiss Contura G2). The last details like blade root radii and anti-singing edges are applied manually.

Pod housings

Pod housings, head boxes and similar parts are either milled from special, water-resistant plastic or made with the 3D printer. Often combinations of the manufacturing processes are used, resulting in higher quality and more versatile components.

Model hull and components provided by the customer or third parties are checked for geometrical accuracy upon request. ■

contact: klug@hsva.de

"Attenborough" in the virtual wind tunnel

HSVA investigated the aerodynamic performance of Britain's new polar research vessel "RRS Sir David Attenborough". Commissioned by the Natural Environment Research Council, designed by Rolls-Royce and being built at Cammell Laird, the ship will be operated by the British Antarctic Survey from 2019.

by Lars-Uve Schrader

"RRS Sir David Attenborough" will serve both as a research platform and a supply vessel in Antarctica and the Arctic. To fulfil these two missions, the vessel will feature an ice-breaking hull, a helideck, scientific equipment for oceanographic and atmospheric research, accommodation for 90 persons and cargo capacity for containers and aviation fuel to name but a few [1]. HSVA extensively analysed the ship design in model tests and computational simulations considering the whole range of services available – among them the "virtual wind tunnel".

Virtual wind tunnel

In recent years, computational aerodynamics developed into an attractive alternative to wind-tunnel tests, offering several advantages: the ship can be analysed in full scale (Figure 1a), the "virtual measurement sensors" do not obstruct the flow field, and the approach is flexible with respect to the wind model (input) and the data post-processing (output). This type of CFD simulation relies heavily on a numerical flow solver with a capable turbulence model as well as a powerful supercomputer. Both ingredients are available at HSVA in the form of the well-proven in-house code ***FreSCo+*** and a computer cluster with approx. 1,200 cores. ▶

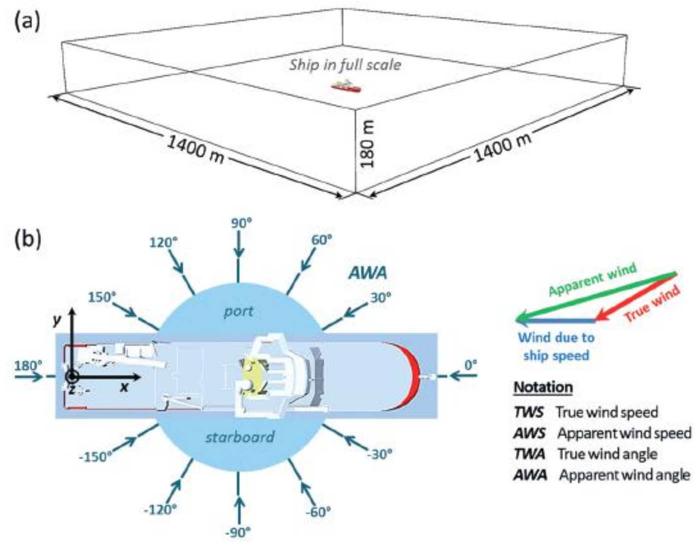


Figure 1: (a) Typical dimensions of the "virtual wind-tunnel test section". (b) Ship on the "virtual turntable" and definition of speed and angle for true wind (TWS, TWA) and apparent wind (AWS, AWA)

The aerodynamic field around a ship is characterised by massive flow separation along with vortex shedding at the sharp edges and corners of the superstructure. Such a flow scenario is well described by Detached Eddy Simulation (DES) [2], a modern turbulence treatment which is superior to the classic unsteady Reynolds-Averaged Navier-Stokes approach (URANS). In DES, the dominant energetic eddies in the wake of the ship are resolved in space and time such that the flow dynamics are captured in detail. This is crucial when studying e.g. the turbulent fluctuations on a helideck or the transport of exhaust gases by the wind.

The "Attenborough" project

The CAD model of "RRS Sir David Attenborough" was first simplified in close collaboration with Rolls-Royce to reduce the computational effort: the underwater hull and small parts of low importance for the flow field such as antennae and railings were removed (see thematic picture on the top of this article). The level of detail of the CFD model was comparable to a typical ship model for wind-tunnel testing. The resulting CFD mesh consisted of some 15 million cells (Figure 2).

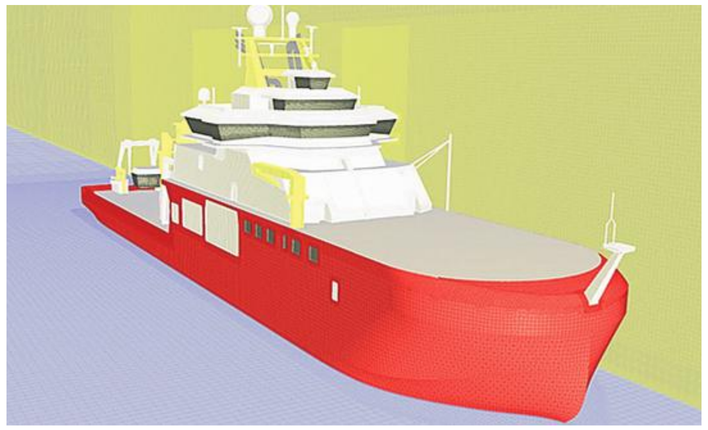


Figure 2: CFD mesh for DES: surface mesh of the ship and two cuts through the volume mesh

The scope of the study was defined by the scientists of the British Antarctic Survey and their partners. Three design aspects were in the focus: the quality of wind measurement at the foremast, helideck safety and exhaust dispersion.

Wind measurement

The foremast will carry most of the meteorological sensors such as the anemometers. These need to be mounted high enough so as to avoid massive distortion of the wind measurement due to flow blockage by the superstructure, calling for a tall mast. On the other hand, the foremast needs to be foldable to allow for safe flight operations on the helideck at the bow, which sets a limit to the size of the mast. HSVA simulated the flow field around the ship for various combinations of ship speed and wind conditions (TWS and AWA; see Figure 1b for a definition), evaluating the vertical profile of mean wind speed above the foremast (two samples in Figure 3). It turned out that the scientists' requirement of anemometer errors below 5% was best met at a level of at least 25m above the water line for all AWA values studied. Rolls-Royce modified the foremast design accordingly by raising the platform and the mast extension.

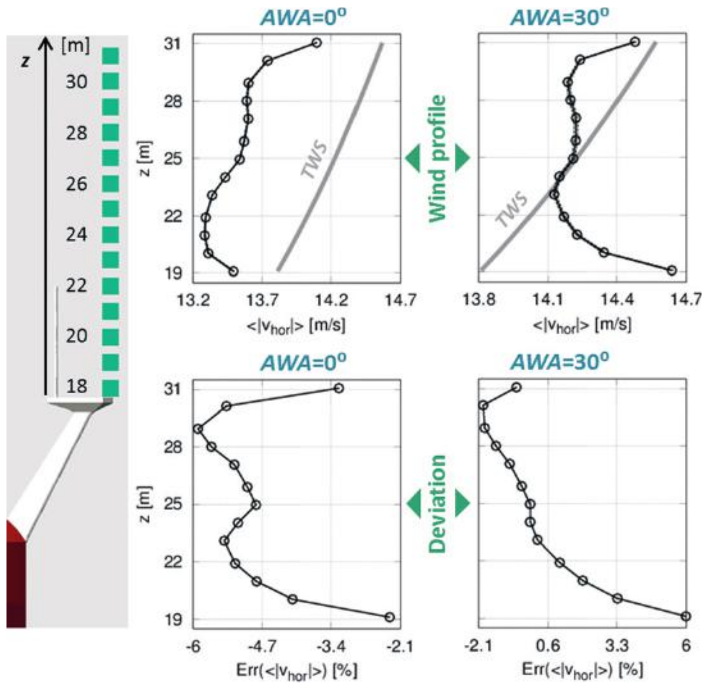


Figure 3: Mean vertical profiles of TWS above the foremast. Measured profiles (black, symbols), target profile (grey) and deviation for two values of AWA (cf. Figure 1b for a definition of TWS and AWA)

Helideck safety

Safe helicopter take-off and landing operations require sufficiently calm flow conditions above the flight deck. HSVA examined the velocity field in various planes near the helideck, considering snapshots and statistical assessment of the flow (sample in Figure 4). This analysis highlighted a large recirculation zone upstream of the superstructure in the present example of AWA=30° (blue regions in Figures 4a-b). HSVA also evaluated the standard deviation of the vertical velocity component as the vertical turbulent fluctuations pose the biggest challenge to helicopter pilots. According to the helideck safety rules by UK's Civil Aviation Authority (CAA), this quantity should not exceed a level of 1.75m/s [3]. In the present example (AWA=30°), the safety criterion was largely fulfilled within the landing area of the helicopter (Figure 4c).

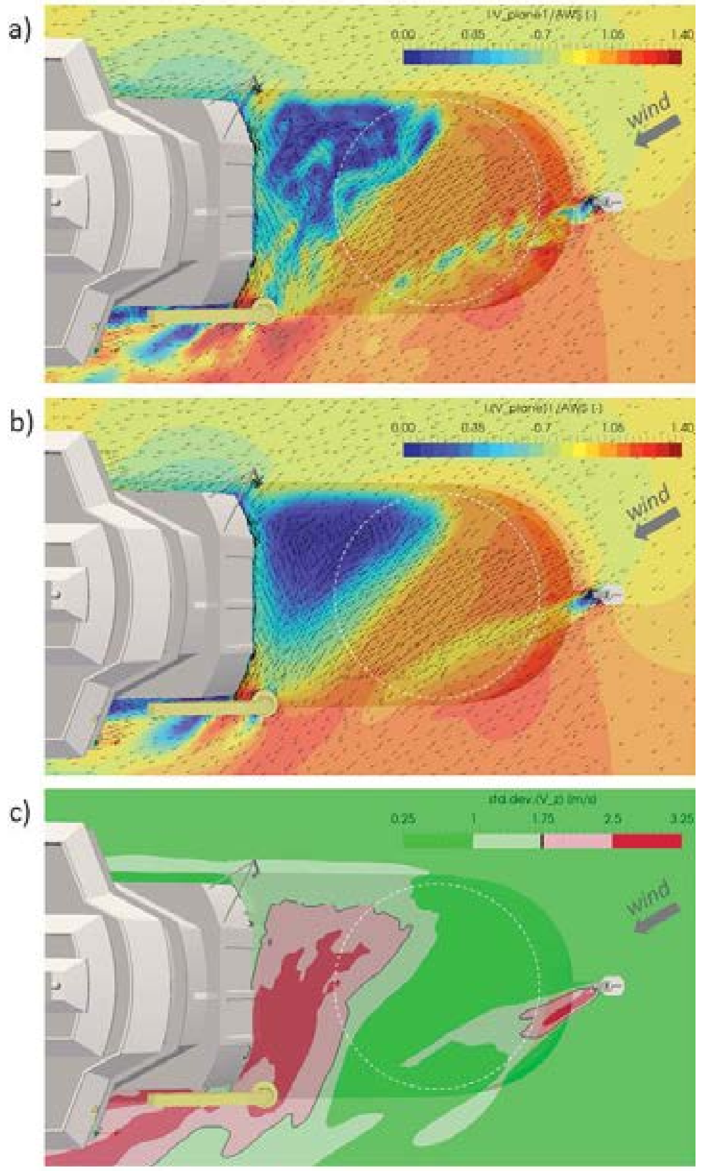


Figure 4: Flow field in a plane 2m above the helideck for zero ship speed, TWS=25kn and AWA=30°. (a) Snapshot and (b) time average of horizontal wind speed (colours) and direction (arrows). (c) Velocity criterion as per the CAA helideck safety guidelines [3]

Exhaust dispersion

A classic part of aerodynamics studies for ships consists in an analysis of exhaust dispersion in the wind field. To this end, HSVA carried out multi-phase flow DES using the volume-of-fluid implementation of ***FreSCo+***. "Smoke videos" were produced in various wind conditions (cf. Figure 5 for a snapshot), revealing that Rolls-Royce's design proposal of the exhaust system performed well on the whole. The helideck, in particular, was not exposed to any significant fallout of exhaust gases in following wind – in line with the corresponding safety criterion by the CAA. However, HSVA detected exhaust concentrations above the odour limit of 300ppm at the air intakes of the engine rooms. Rolls-Royce modified the exhaust system according to HSVA's recommendations, which solved the problems as demonstrated in verifying simulations.

Summary

The "virtual wind tunnel" is a new HSVA service based on modern CFD tools and computational resources. The present report highlights a few selected results from a recent industrial project in collaboration with Rolls-Royce Marine AS and the British Antarctic Survey, dealing with the aerodynamic analysis of Britain's new polar research ship "RRS Sir David Attenborough". HSVA believes that computational aerodynamics is an attractive alternative to experimental investigations; CFD may serve as a complement of – or even a substitute for – wind-tunnel testing. To date, HSVA has conducted four industrial projects in the "virtual wind tunnel" to the customers' full satisfaction. ■

HSVA thanks Rolls-Royce Marine AS, Ålesund (Norway), and the British Antarctic Survey, Cambridge (UK), for their permission to publish the present results and pictures of "RRS Sir David Attenborough".

[1] Leenders E, de Jongh M, The Naval Architect, January 2017, pp. 37-38
[2] Spalart PR, Annu. Rev. Fluid Mech. 41, 2009, pp. 181-202
[3] Civil Aviation Authority, CAA Paper 2008/03, UK, 2009

contact: schrader@hsva.de

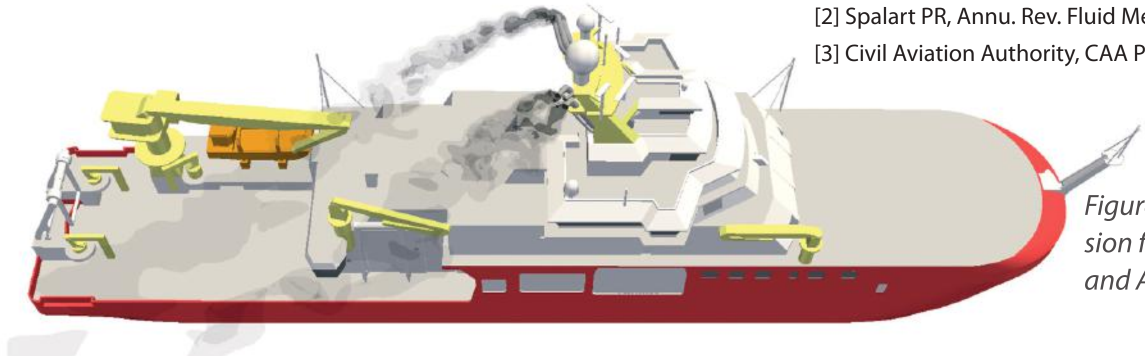


Figure 5: Snapshot of exhaust dispersion for zero ship speed, TWS=25kn and AWA=30°

HSVA successfully provides interdisciplinary services for the Expedition Cruise Vessel Market

Latest developments in the cruise vessel market show major interest in specialised Expedition Cruise Vessels. The already complex and challenging design of cruise vessels due to manifold demands of comfort and efficiency is even intensified by further requirements such as performance in ice or hard weather conditions.

by Johannes Strobel and Oliver Reinholz

HSVA is proud to proclaim its successful cooperation with several well-known and experienced designers and shipyards such as Rolls-Royce, VARD and MV Werften in the development and model testing of expedition cruise vessels designed for Hurtigruten, Hapag-Lloyd Cruises, Crystal Cruises, Compagnie du Ponant and others.

Besides the 'standard' test scope covering calm water and cavitation model tests, several further investigations become necessary when aiming at an integrated and all-embracing ship design taking into account all various demands of a cruise vessel operating in challenging conditions. HSVA is able to cover the complete work scope in-house and thus ensure the consideration of each particular discipline. Taking into account different requirements for different disciplines often ask for design trade-offs. Whereas for example a deeply submerged transom tends to be unfavourable with regard to the vessel's ahead performance and manoeuvrability in ice, it is beneficial considering minimising the risk of stern slamming. A beneficial bulbous bow in calm water conditions for example does not necessarily result in a favourable performance in ice.

Additionally to the challenging design requirements, latest safety regulations for passenger ships should be considered in the early design phase already. Therefore, HSVA established a procedure for the determination of the "Safe Return to Port" performance, which includes model tests for single-shaft propulsion as well as thorough investigations of additional resistance components in rough weather conditions.
The combination of HSVA's valuable and experienced customers and HSVA's extensive expertise and experience in all fields of ship design and operation proved to be a very fruitful cooperation which finally resulted in highly sophisticated ship designs. ■

contact: strobel@hsva.de / reinholz@hsva.de

CALM WATER TESTS

- Experimental Optimisation of Appendages and Propulsion Arrangement
- Wake Field Measurements
- Speed-power Prediction

HYDRODYNAMIC CFD

- Hull Form Optimisation
- Optimisation of Propulsion Arrangement
- Numerical Paint Flow

CAVITATION TESTS

- Pressure Pulses
- Propeller Cavitation
- Cavitation Inception
- Rudder Cavitation
- Noise / Vibration

MANOEUVRING TESTS

- Zig-Zag Tests
- Crabbing Capability
- Hydrodynamic Coefficients for Simulation

SEAKEEPING TESTS

- Ship Movement / MSI
- Slamming Forces
- Anti – Rolling Devices
- Safe Return to Port
- Zero Speed Tests
- Extreme Seas

ICE TESTS

- Brash Ice / Level Ice
- Impact on Propellers
- Added Resistance

AERODYNAMIC CFD/TEST

- Wind Comfort
- Smoke Dispersion
- Forces / Moments

FULL SCALE CONSULTATION

- Speed Trials
- Manoeuvring Trials
- Consulting

Good Cooperation between MARIC and HSVA

It's my pleasure to have chance to visit world-famous towing tank-HSVA for the first time during Hamburg SMM Exhibition 2016.

by Xing Wenhua

Many thanks to President, Dr. Jannou Hennig, who enthusiastically showed me around the characteristic circulation tunnel, ice tank, and other test facilities, which left me deeply impressed.

After that, Marine Design and Research Institute of China (MARIC), the first marine design and research institute in China, and HSVA have carried out sincere cooperation in luxury cruiser and other projects. During the cooperation, HSVA has made great effort to push forward the projects. Many gratitude to HSVA for kind help, and I'm very satisfied with our relationship.

Currently, MARIC is engaged in many research projects, including Polar vessel, Luxury RoRo ships, etc. May I suggest following projects for further cooperation with priority?

- **Polar vessel, including line optimization, icebreaking performance evaluation, ice test etc.**
- **Luxury RoRo ship and government ship, including vibration and noise reduction, sea-keeping evaluation and optimization etc.**
- **Other research projects.**

Meanwhile, MARIC has built a relatively smaller circulation tunnel with free surface for water-jet vessel this year. Technical exchange and lecture on circulation tunnel is another cooperating point.

In addition, at the beginning of this year, I was elected as the chairman

President of MARIC and SSNAME, Xing Wenhua

of Shanghai Society of Naval Architects and Marine Engineers (SSNAME), which is responsible to organize MARINTEC CHINA 2017. I'm happy that HSVA attends this grand event. HSVA is an important member of the German Society for Marine Technology (STG), and STG has established long-term cooperation with SSNAME. I'm convinced that we can cooperate on another platform.

Welcome all my distinguished guests to Shanghai and wish you a most rewarding visit.

With best regards from Xing Wenhua
President of MARIC and SSNAME

Enhancing Our Capability with the Help of HSVA

Under owner's demand on lower fuel oil consumption and maritime requirements on environment protection, during the last decade, 'optimization' is the most important key word for ship design.

by Hu Jin-tao

SDARI managed to build our state-of-the-art optimizing capability in hydrodynamic field since 2004, and from then on a stronger team, a bigger database and more advanced software have been chased. Nowadays a Numerical Model Basin far beyond just simulating model test is being built by SDARI.

During this whole stage, we have been getting strong supports and good helps from HSVA which is our strategic partner. We perform tests of container vessels, bulk carriers, multi-purpose vessels and tankers in HSVA. We purchased propeller code and get propeller design support from HSVA. We expand our knowledge on cavitation performance, rudder design and brush ice test with the help of HSVA. At the very booming time of shipbuilding industry, we even reserve at least a two days slot each month in HSVA. Always good partners of HSVA are very experienced, efficient and patient, their quick response and professional proposal enhanced our capability and reputation. The co-operations with HSVA are pleasant and fruitful.

With state-of-the-art CFD tool and CAE tool for parametric modelling, we practiced quite a lot on hull line optimization. For these optimizations not only resistance but also wake quality and even propulsion efficiency should be taken into account. We use partial parametric model as well as fully parametric model to generate and vary hull shapes. Then CFD code is coupled and used to evaluate all the variations. We continue to proceed on this way. Many of these hull lines have been tested in HSVA who is trusted and highly appreciated by owners. Tested ship types include the long series of our container vessels such as 19700TEU, 16000TEU, 14000TEU, 6700TEU, and feeder

President of SDARI, Hu Jin-tao

designs, multi-purpose vessels, bulk carriers and oil tankers etc. For some ships such as 12,500dwt Multi-Purpose Vessel, HSVA gave owner optimization proposals as an independent consulting partner. Owner is very satisfied with this efficient consulting service of HSVA.

We also have a special team that uses CFD more professionally. They focus on the complex flow from strong interactions among hull, propeller, rudder and other appendages. With the help of this team, we know more about where we lose more energy from and how to recover or fix it. We have successfully developed our own pre-swirl system FAN DUCT, our own propeller cap fins FAN CAP and our own twisted leading edge rudder. Both our FAN DUCTs and twisted leading edge rudders benefit from the cooperation with HSVA and have been tested in HSVA. HSVA's experience and good test accuracy give us confidence of how to improve them. Our first Fan Duct was tested in HSVA coupled with a VLCC hull line. The best sold Fan Duct on Green Dolphin 38 was also tested in HSVA. Cooperating with HSVA, we developed the twisted leading edge rudders for the 5100TEU container vessel built in Jiangnan Shipyard. And recently we tested a new concept twisted leading edge rudder on Bangkokmax feeder container ship in HSVA. The result gives us good confidence.

HSVA is also good at cavitation test and brash ice test. Many designs tested in towing tank were also confirmed by HSVA's big cavitation tunnel. HSVA's experience helps owners and SDARI to build the confidence of existing design as well as to give good proposal of improvements. Up to now, we have the experience to perform brash ice tests in HSVA for our tankers and multi-purpose vessels. ▶

But sooner or later we will test a miniCape bulker in their good ice towing tank. HSVA can make very good prediction of required power before formal test that helps us quite much for determining main engine much early.

Definitely we at SDARI enjoy the cooperation with HSVA so much that it's our pleasure to introduce HSVA to more owners and partners.

Hu Jin-tao
President of SDARI

HSVA supports customers to reliably reach a safe harbour

In 2010 the Safe Return to Port (SRtP) regulations formulated by the International Maritime Organisation (IMO) became mandatory for the newly built large passenger vessels with a length of more than 120 m or having three or more main vertical fire zones.

by Johannes Strobel

Considering the slogan "***A ship is its own best lifeboat***", plenty of safety requirements have been formulated which have the goal to ensure the capability of the vessel to reach a safe port in unfavourable weather conditions, even if it has suffered a serious incident (fire/flooding). Among several regulations regarding the redundancy of supply systems like water, electricity and air ventilation, the SRtP regulations also state, that the "propulsion machinery and auxiliary machinery essential for the propulsion of the ship should remain operable" (MSC.1/Circ.1214) after a fire or flooding casualty. This means, that for safe return to port operation, at least one independent propulsion system including its auxiliaries has to remain operational.

As many large passenger ships are driven by two or more propulsion devices (FPP, CPP, Azimuth Pods), they have fortunately favourable qualifications with regard to redundancy aspects. If one propulsion plant fails due to fire or flooding casualty, at least one further remains operable and might preserve a sufficient manoeuvrability and the capability to get back to a safe harbour even in unfavourable weather conditions. However, it is a crucial aspect to get insight of the single-shaft propulsion condition already at an early design stage in order to provide a suitable propeller/engine layout and to provide sufficient propulsion power in the case of an emergency.

In order to get a most reliable and accurate prediction of the SRtP performance in the early design phase, HSVA has developed a concept of analysis consisting of theoretical and experimental investigations. The procedure, as described in the following, is explained by assuming a vessel fitted with a propulsion plant consisting of two shafts and two controllable pitch propellers. However, basically the general procedure remains unchanged considering other propulsion concepts (i.e. two azimuth pods, two fixed pitch propellers, more than two propulsors).

Test procedure

The procedure to reliably predict the SRtP propulsion performance under unfavourable weather conditions basically consists of two phases.

- **Calm water model tests for the intact propulsion**
- **Calm water, seakeeping and wind tests/investigations for the SRtP condition.**

First phase

The first phase is basically part of the 'standard' investigation for most of the vessels tested at HSVA. During this phase an initial calm water resistance test on design draught is carried out as well as a conventional self-propulsion test with both propellers (mostly stock propellers) operating. Both tests should cover the entire speed range of the vessel including SRtP speed. The analysis of the intact self-propulsion test for the SRtP speed in combination with certain assumptions of added resistance in SRtP conditions is a valuable first estimation of the expected propulsive condition in which the one remaining propeller will work during the SRtP condition. The findings of the first test phase are valuable information with regard to a proper propeller/engine layout including possible pitch adjustment of the controllable pitch propeller during the single shaft propulsion.

As the results of the first phase are not very accurate due to several assumptions and approximations, HSVA strongly recommends carrying out further investigations towards the single shaft propulsion in calm water as well as a detailed determination of the three added resistance components due to the disabled propeller, waves and wind.

The second phase

The second phase of the SRtP investigation consists of a self-propulsion test with only one propeller operating and the other propeller removed – called the single-shaft propulsion – and the detailed determination of the additional resistance components which occur during the SRtP condition.

Single-shaft propulsion

The single-shaft propulsion test is carried out in calm water conditions and should cover the relevant SRtP speed. During this test, the rudder or the pod unit, respectively, should be adjusted in such a way that the vessel is going straight ahead. The evaluation of the single-shaft propulsion test together with the conventional resistance test carried out during phase one results in a speed-power prediction for the single-shaft propulsion in calm water conditions.

Additional resistance components

In order to accurately predict the required power for the single-shaft propulsion in SRtP condition (one propeller disabled, unfavourable weather conditions), the following three additional resistance components need to be determined:

- **Additional resistance due to second propeller**
  - **Watermilling (driven by the inflow of the water)**
  or
  - **Blocked (Not rotating)**
- **Additional resistance due to waves**
- **Additional resistance due to wind.**

In order to consider the relevant working scenario for the second propeller, it should be discussed and clarified by the classification society in cooperation with the shipyard, whether the second propeller is assumed to be water milling or blocked.

HSVA has developed a procedure to determine the additional resistance of a watermilling propeller accurately. In reality, a watermilling propeller will operate at a turning rate where the propeller torque equals the resistance on the propulsion train. As it is hardly possible to accurately simulate the full scale shaft friction for a watermilling propeller during model tests, HSVA's approach is to carry out a propeller open water test for high advance coefficients J (ratio of propeller inflow velocity and rotational speed). At this condition, the propeller is driven by the water inflow and thus a negative thrust, which means resistance, and torque is measured. Considering the full scale frictional torque of the propulsion plant (kQ), the corresponding resistance (kT) of the watermilling propeller can be determined via kQ-identity. ▶ It remains to be checked if the obtained turning rate for that condition is larger than the minimum propeller turning rate that is required to maintain sufficient shaft bearing lubrication.

The additional resistance of a blocked propeller is determined by carrying out a resistance test with two blocked



propellers and comparing the results with the results of the resistance tests without propellers.

Besides the additional resistance of the second propeller, a special attention should be paid on the additional resistance in waves. Depending on the vessel's hull form and main dimensions this part can play a leading role on the overall resistance in SRtP conditions. In order to determine this particular resistance as accurate as possible, HSVA is carrying out resistance tests in irregular head seas in the large towing tank. As the 'unfavourable weather condition' is not further described in the SRtP regulations, the investigated wave heights and periods differ between several projects. The decision about the most relevant wave condition is made depending on the service area and probability of occurrence to be agreed with classification society individually.

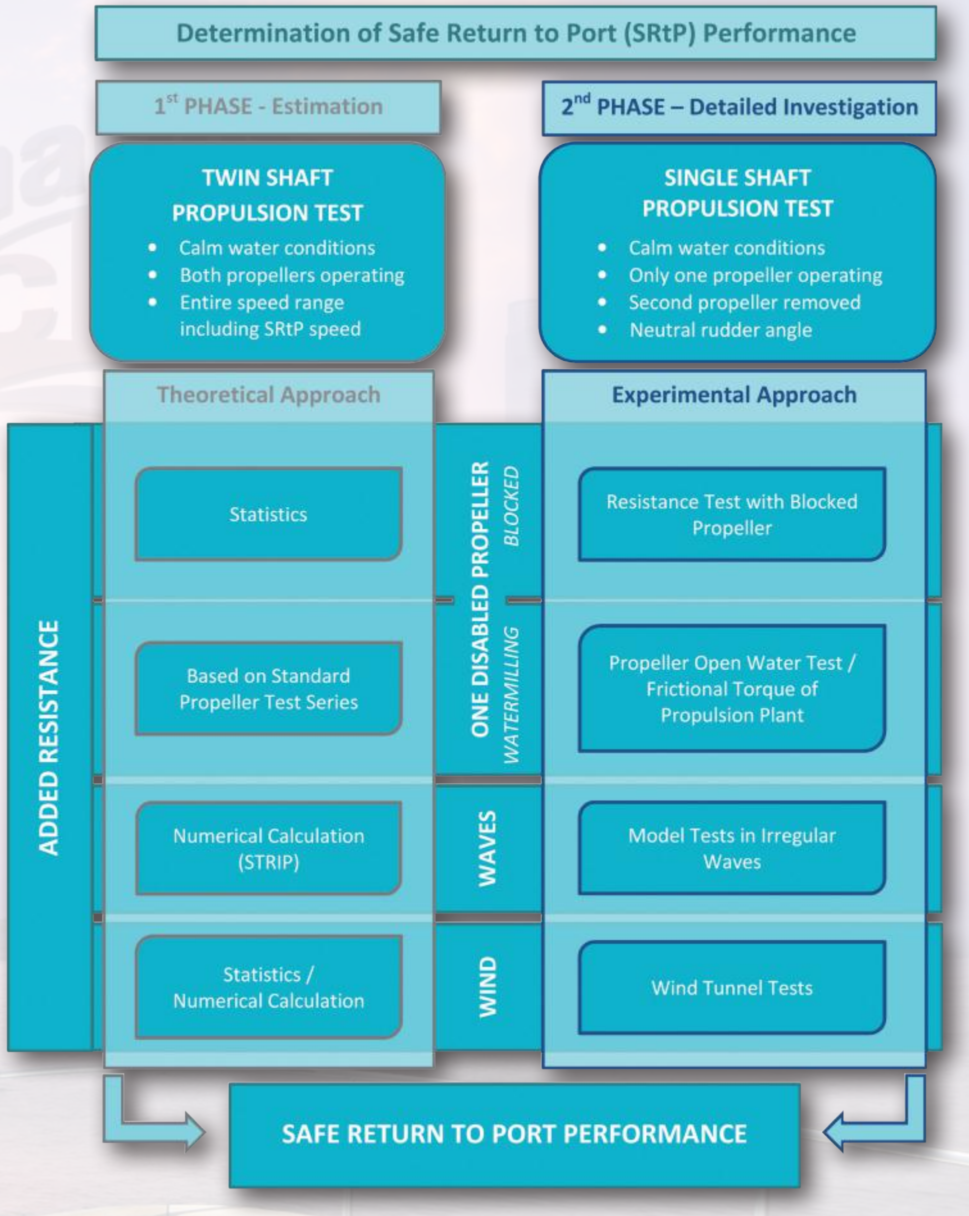
The third part of the additional resistance in SRtP conditions is the wind. Basically three different approaches are considered which are all connected to different expenditure and accuracy.

- **Wind tunnel tests**
- **Numerical calculation by CFD**
- **Statistical calculation by wind resistance coefficients.**

The decision about which approach is most reasonable for each project should be made in the context of further investigations which are planned anyway. As for many cruise vessels for example, thorough wind tunnel tests with regard to smoke dispersion are carried out anyway, it is reasonable to determine the wind forces in the same course.

Total SRtP performance

Having determined the additional resistance components in SRtP conditions (one propeller disabled, unfavourable weather conditions), the total performance will be predicted by adding the additional resistance components to the conventional 'bare hull' resistance obtained in phase one. Finally, the total resistance together with the thrust deduction fraction t obtained from the single-shaft propulsion test as well as the full scale wake fraction w and the propeller open water test result in an accurate prediction of the delivered power in the specified sea state and wind condition.



Although carrying out model tests is practically the best and most reliable way to predict the SRtP performance, it is worth to perform a first prediction by computations already when the vessel is still in the very early design phase. As for each individual project, different requirements considering propulsion concept and weather conditions as well as project phase, budget and time apply, HSVA offers tailor-made solutions for the determination of the SRtP power performance.

contact: strobel@hsva.de

Propeller-Ice Interaction as a Design Aspect of Cargo Ships

The good performance of a ship navigating in polar waters is generally reflected by a low ice resistance, a high propulsion efficiency and the ability to maintain continuous motion while breaking ice. Propeller-ice interaction is one of the main factors to be accounted for regarding operational efficiency and risk of damages.

by Nils Reimer and Quentin Hisette

The ice floes reaching the propeller are affecting the ship's propulsive efficiency and the ice impact loads on the propeller. Both aspects are strongly depending on the hull shape design, besides the ice properties and the ship's speed. In order to assess the significance of this problem for a specific design the probability and expected frequency of occurrence are to be determined. Therefore the entire process of ice breaking by the bow, ice clearing and ice flow along the hull to the propeller area should be analysed. In a second step the ice influence on the propulsion parameters and the load level of ice impacts on the propeller have to be investigated in order to draw conclusions for the designer.

The propeller-ice interaction process is currently studied within the research project ProEis funded by the German Federal Ministry of Economic Affairs and Energy. The project consortium is led by HSVA and includes partners like MMG, MV Werften, Voith Turbo and DNVGL with strong experience in marine design and load analysis of propulsion trains.

The work scope includes several model testing campaigns to investigate the relation between bow geometry, breaking pattern and ice coverage (Figure 1), the ice

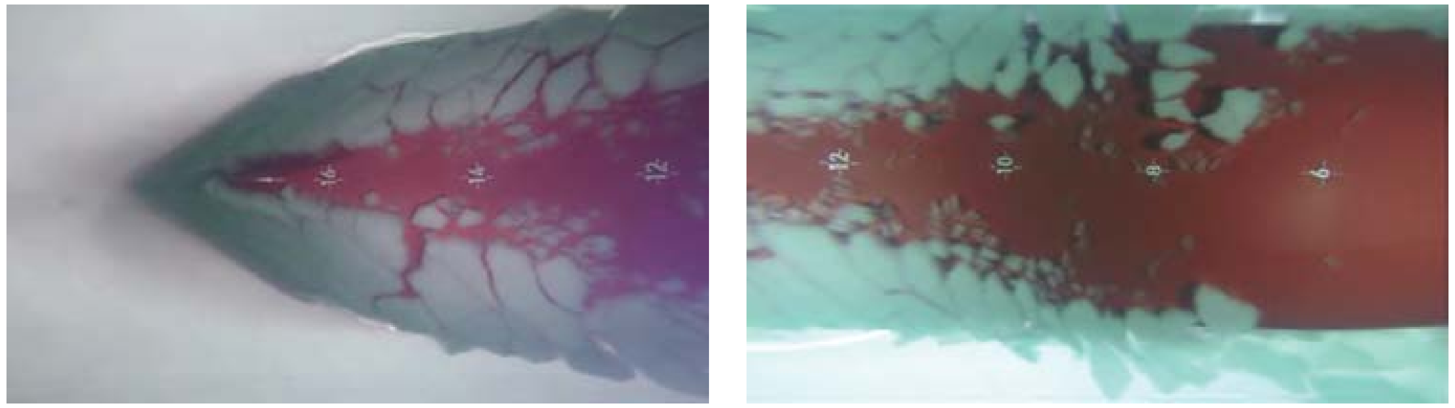


Figure 1: Investigation of ice flow along the hull to determine the influence of bow geometry

milling by controlled ice feeding into propellers (Figure 2 and 3) and the propeller-ice interaction in a natural flow situation at the aftship (Figure 4). A numerical investigation of the interaction of ice in the flow field of the propeller is contributed by the Hamburg University of Technology. One of the main objectives of the project is to obtain design tools for hull shape analysis with respect to ice clearing and prediction of probability of propeller-ice contact. As further achievements the hydrodynamic impact from ice fragments into the pro- peller(s) can be simulated, and load characteristic during impact can be analysed and used as input for structural analysis and dynamic calculations.

For the test campaign ship models of icebreakers or icebreaking supply vessels were used as these vessels usually enter ice covered waters more frequently. Still there is also a probability for cargo ships to encounter propeller-ice interaction as there is an increasing tendency from ship operators to occasionally navigate on

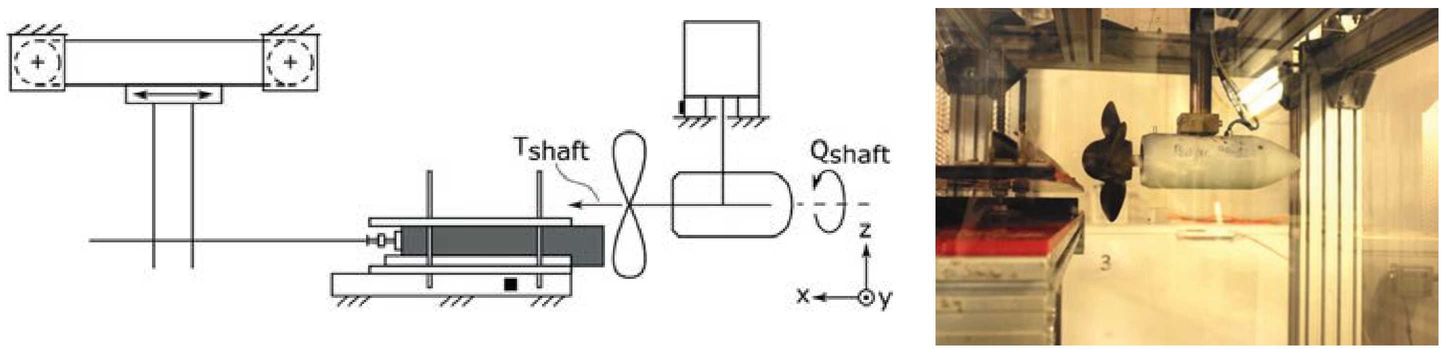


Figure 2: Ice feeding appliance used for milling tests

Figure 3: Torque signals for different types of propeller blade interaction during ice milling tests

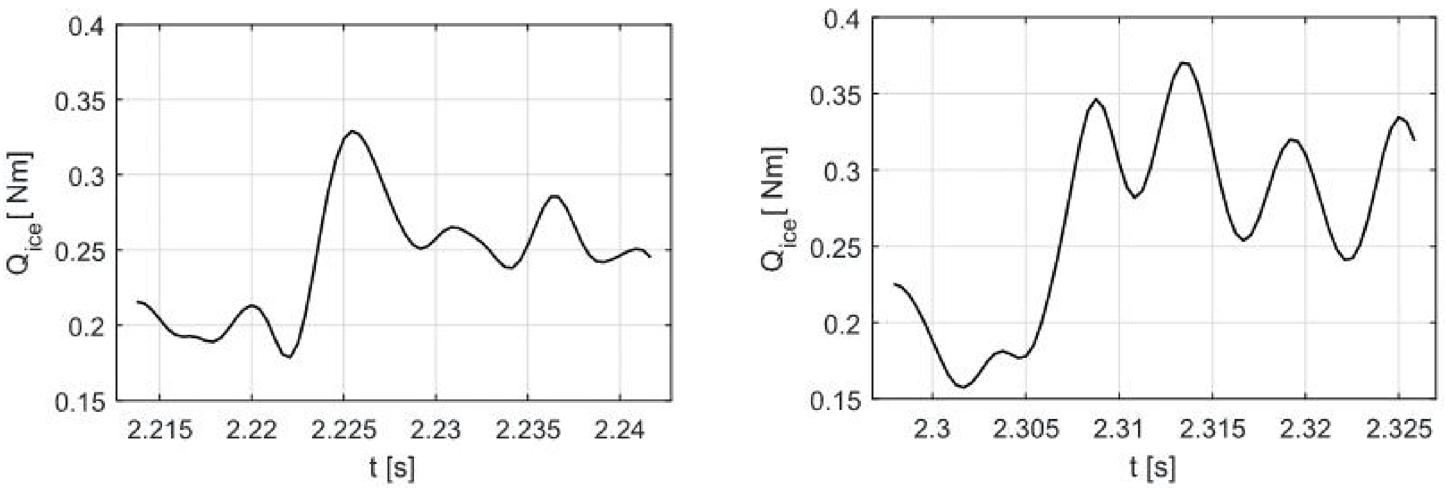


Figure 4: Ice flow into podded drives of an icebreaking supply vessel

arctic routes in the summer period. Additionally irregular ice formations like broken ice and brash ice are more likely to reach the flat bottom and be directed towards the propeller than level ice that breaks at the bow and is cleared earlier in a more controlled way (Figure 5).

The design of the cargo ships used in polar waters typically ranges from moderate ice class with simple ice going capability to real icebreaking hull geometries at fore- and aftship. As 70 to 90 percent of the operation time is assumed to take place in ice free waters the objective for the designer is to achieve the highest possible efficiency in open water with simultaneous applications of ice requirements. The optimisation for ice should therefore focus on allowing reliable and safe operation in ice while maintaining an acceptable efficiency. This can be achieved by avoiding severe manoeuvring limitations resulting from either a high ice resistance, inability to change course, extensive ice coverage of the hull and disfunctions of propulsion and manoeuvring systems (avoidance of propeller-ice interaction).

For dedicated icebreaking vessels optimisation typically includes following aspects:

- **Optimisation of bow or bulbous bow geometry to avoid ice crushing and reduce breaking resistance**
- **Optimisation of underwater bow geometry to efficiently clear broken ice floes from the hull**
- **Adjustment of fore shoulder to achieve a sufficiently wide broken channel**
- **Minimise length of parallel midbody to facilitate turning and course changing in ice**
- **Adjustment of aftship geometry to allow manoeuvring and backing in ice**
- **Optimisation of the arrangement of propulsion and manoeuvring systems at the aftship including appendages (bossings, propeller, rudder, headboxes, ice knifes).**

For most cargo vessels the above mentioned criteria are difficult to be met since compromises have to be made with regards to other requirements (e.g. cargo hold length, restricted length of aftship, operation in ballast loading condition, calm water performance). For these vessels it is therefore even more important to evaluate and manage the risk of propeller-ice interaction already in the early design process. ■

contact: reimer@hsva.de / hisette@hsva.de

Figure 5: Bow coverage in level ice (left) and brash ice (right)

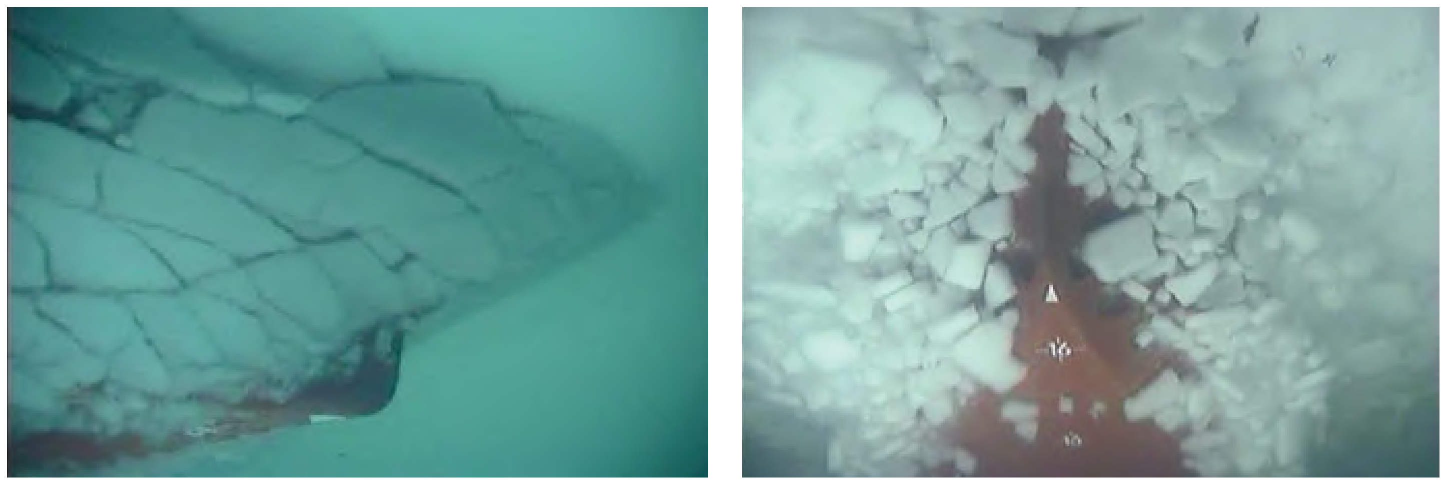


Figure 1: Hull form -> Panelisation -> Case setup -> Computation -> Result visualisation

Full Speed Ahead with HOLISHIP

During its first year the EU funded project HOLISHIP – *Holistic Optimisation of Ship Design and Operation for Life Cycle* saw many interesting tool developments and integrations into the HOLISHIP platform by HSVA and other project partners.

by Joerg Brunswig and Jochen Marzi

Having introduced HOLISHIP in the previous NewsWave issue 1-17, the project has now reached a stage where first tools have been integrated and early simulation and optimisation results can be presented. In this issue, we would like to focus on CFD based developments performed at HSVA and in direct collaboration with partners in the scope of HOLISHIP's Hull Form, Stability and Hydrodynamic Performance work package.

To analyse the hydrodynamic features of a hull form in calm water and find ways to improve the lines, designers most often make use of numerical methods based on potential flow as well as more sophisticated RANSE solvers. HSVA's tools of choice are the well-established in-house simulation tools ν-Shallo and *FreSCo+*. However, improving a hull form is barely ever just a matter of optimising the hull resistance and propulsion alone. Instead, many other aspects must be considered, such as rules and stability issues, geometric restrictions regarding the main particulars, cargo holds and many more.

The new HOLISHIP platform allows to model the interaction between all the relevant design disciplines and constraints which all together define the complex system known as a ship, while keeping track of all interdependencies and ensuring a consistent and valid model at any time.

The first hydrodynamic tool integrated in the platform was ν-Shallo. The process consists of creating the panelisation (a suitable geometric representation of the hull form), the integrated setup of simulation parameters and finally the post-processing of results inside the platform.

At the same time, the tool itself was updated to exploit modern computer architectures by enabling the use of multi-core CPUs. The parallelisation of the code was realised using a shared-memory approach. Manual design changes as well as automatic optimisation runs significantly benefit from accelerated simulation tools like ν-Shallo. The technical step of going multi-core also allowed HOLISHIP partner Friendship Systems to integrate ν-Shallo as a so-called WebApp. In this setup ν-Shallo is installed on a multi-core Linux server, accessible via a webpage configured to show and edit a specific model, in this case the parametric model of a RoPax ship. The user can adjust a number of parameters, instantly view the changes of the hull geometry and finally trigger the hydrodynamic analysis. The App will soon be available through the project's website at ***www.holiship.eu***

Two other tools developed and integrated by HOLISHIP partners but available to engineers at HSVA shall be mentioned here.

The first one is NEWDRIFT, a potential flow software to determine drift forces on ships and structures in a seaway. The software uses the same hull form definition format (panelisation) used in ν-Shallo and has recently been extended to calculate added resistance in linear seaway. Therefore, NEWDRIFT in its latest version is a perfect supplement of HSVA's calm water resistance software. Development of the tool is currently driven by the National Technical University of Athens (NTUA) being a partner in HOLISHIP.

The second tool is the well-known naval architecture package NAPA. A growing set of macros, developed by Hochschule Bremen (HSB) and NTUA, are used to establish the integration into the HOLISHIP platform, making the vast possibilities of NAPA accessible to the HOLISHIP design process. The most important modules cover instact stability assessment, the definition of the ship's compartmentation and damage stability calculations.

In addition to the use of direct predictions using tools such as CFD or stability codes, HOLISHIP explores the use of response surfaces as a means to distribute data in a collaborative design.

The response surface method provided in the HOLISHIP integration platform can be used to characterise and share the behaviour of an objective function with respect to a given set of design parameters. ▶

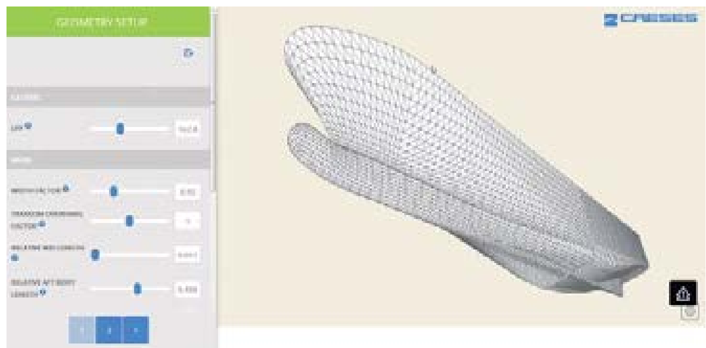


Figure 2: Design parameters and hull form

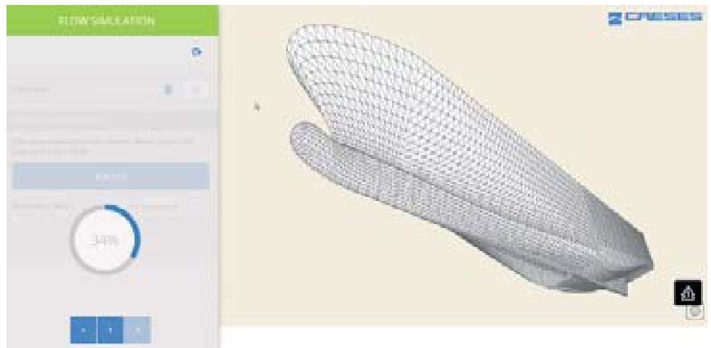


Figure 3: Running a CFD simulation

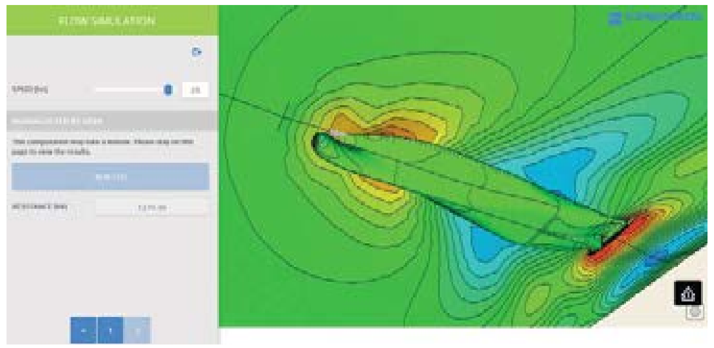


Figure 4: Visualisation of CFD results in the WebApp

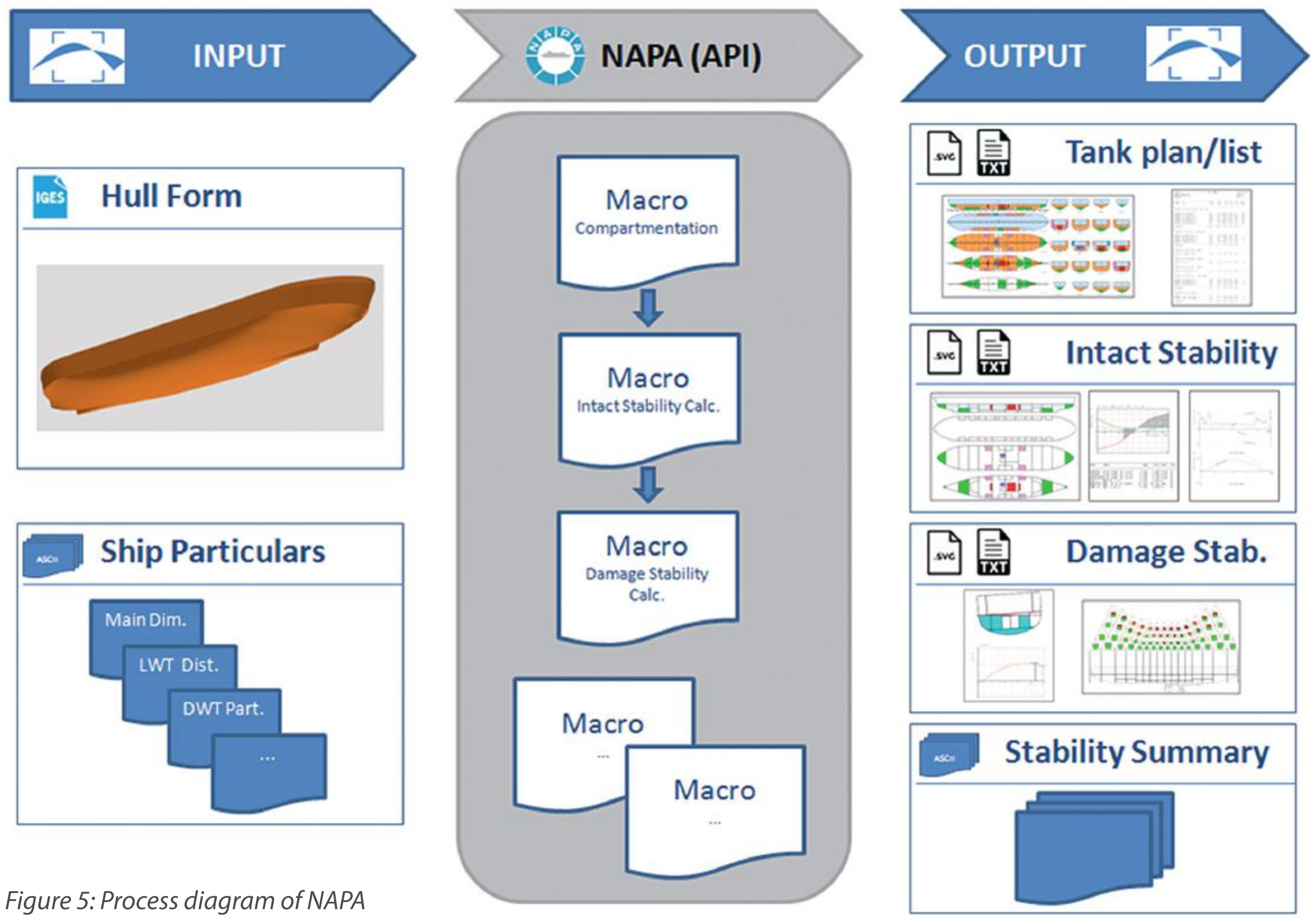


Figure 5: Process diagram of NAPA integration (courtesy of Hochschule Bremen)

The starting point is a design of experiment (DoE), carried out at one site. The results of this DoE can then be used at a different site (another HOLISHIP partner, another department in a shipyard, a customer etc.) in the form of a response surface and combined with other numerical tools to allow multiple design disciplines to be considered in a single optimisation procedure. This approach allows for load balancing during different design steps and for partners with complementary expertise to work together in a multi-disciplinary environment.

Having achieved the potential flow code integration into the platform, the next logical step for the project will be the extension of the CFD toolbox to viscous codes. For HSVA the RANS code ***FreSCo***$^+$ including the integration of its pre- and post-processing tools Hexpress and ParaView will be the next move towards holistic CFD simulations.

The short term perspective of HOLISHIP developments aims at streamlining process chains and integrating numerous tools to increase the efficiency of a multi-disciplinary design approach. In the long term, HSVA envisions to connect our customers to the platform to benefit from the innovative techniques developed in HOLISHIP thus allowing a closer link and improved design data consistency at both sides. The increased effiency of this interaction shall be accompanied by new services by HSVA offered via the platform. ■

contact: brunswig@hsva.de / marzi@hsva.de

On the Challenge to Interpret and Scale Propulsion Tests

To arrive at a power prediction for a new ship design and a related adapted propeller, usually model tests are conducted and evaluated. The European project INRETRO aims to provide numerical support for the evaluation of these experiments. Especially the interpretation and scaling of the test results should benefit from the numerical work.

by Heinrich Streckwall, Tom Luecke and Yan Xing-Kaeding

To correlate the propulsion mode with the isolated tests on hull resistance and propeller open water performance the propeller/hull-interaction may be broken down to the 'small figures' i) thrust deduction t, ii) wake fraction w and iii) relative rotative efficiency η_R. The latter (η_R) is considered a quality indicator for the adaptation of the propeller to the propulsion task, comparing power for in-behind and open water conditions at thrust- and RPM-identity.

Within the European project INRETRO we studied the sensitivities of this parameter. The results presented below tend to doubt its pure 'quality'-link. They support to study in detail how η_R reacts on specific arrangements like propeller shafting and propeller/rudder-formation. It turns out, that a comprehensive η_R-analysis requests careful control of geometrical similarity with the experimental situation. For a final comparison of calculations and tests it is even considered necessary to take a cautious view at the processing of the experimental results.

Propeller Open Water Case

The open water (OW) test setup represents a unique case to treat a rotating propeller twofold using a single grid rotating on the whole or a rotating sub-grid combined with a stationary background grid. Using the in-house RANS solver ***FreSCo***$^+$ we realised these two alternatives. Propeller CPP 1304 of the Potsdam Model Basin (SVA) served as test case.

An extra challenge came up, when we looked at the correlation of measured and calculated OW data. KT-data taken traditionally from the OW tests are the so called 'hub corrected' values, labeled 'EFD_Blades' further below. They served as reference when we set up our KT-comparison initially (Figure 1, left on the following page). However it was essential (and in this case possible due to the available extended OW test tables) to correlate KT- and KQ-results explicitly ►

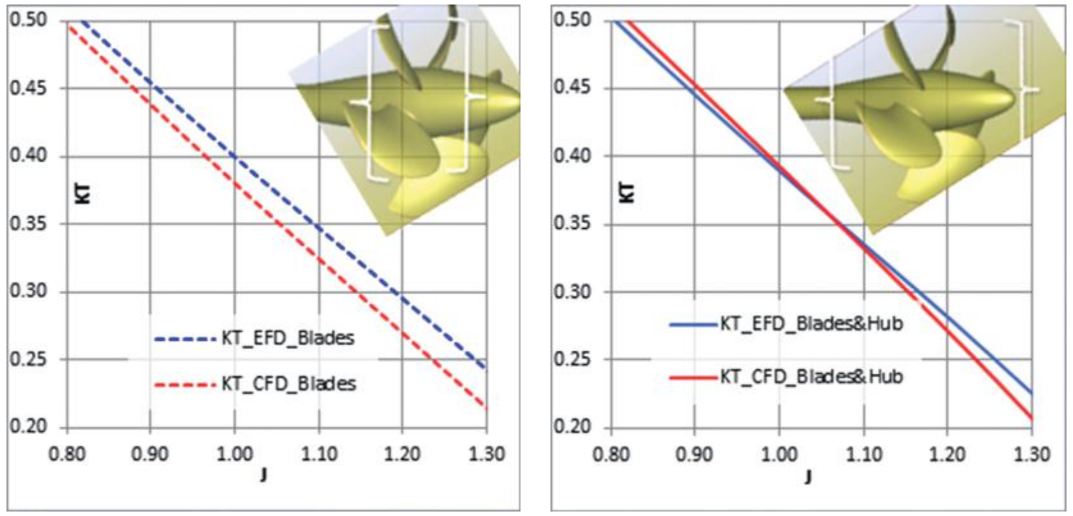


Figure 1: Calculated open water KT vs provided experimental data. On the right (CFD_Blades& Hub vs EFD_Blades& Hub) all rotating parts are referenced, on the left only blades contribute (CFD_Blades vs EFD_Blades). 'EFD_Blades&Hub' reference pure measured data, 'EFD_Blades' corrected data.

linked to the 'Blades&Hub'-contribution. Doing so indeed improved the correlation as can be read from the right diagram in Figure 1.

CPP 1304 was moreover tested in homogeneous flow with the shaft 12° inclined. We considered this inclined setup as the first reasonable η_R -example. The numerical study led to two findings. First, for KT and KQ we observed a good agreement of experimental and numerical data (Figure 2, left). Second, the numerical η_R ranged very close to 1.0 (Figure 2, right). The latter holds, though the time history for the single blade thrust shows strong sinusoidal fluctuations.

Propeller CPP 1304 behind a Twin Screw Vessel

A shared numerical self-propulsion study on a twin screw case using the RANS solvers '**FreSCo+**' and 'Fluent' was done by the INRETRO-partners. To avoid potential problems on property rights we combined the DTMB (David Taylor Model Basin) model No. 5415 with the propeller CPP 1304. A numerical 'British Method' served to find the self-propulsion point.

Before '**FreSCo+**' and 'Fluent' calculations started, the in-behind setup was prescribed in terms of model speeds, geometry of hull and appendages, propeller position as well as propeller blade- and hub-details. The connection of the rotating propeller to the cylindrical strut barrel was however not detailed. For the scenario treated with **FreSCo+** initially, a gapless fitting was set at that point while in the 'Fluent' setup a complete gap was modelled. The thrust result showed a strong response to this mesh detail and so did the so-called 'small figures', in particular the 'relative rotative efficiency' η_R and the wake fraction.

The **FreSCo+** analysis was recently done with gap as well. In this study a shaft was added, closing the gap near the axis. Post- processing the results and using various options to define a thrust the η_R -results given in Figure 3 were obtained. The treatment of the gap between the hub and the strut barrel (modelled or not) doesn't influence the self-propulsion point (in view of the resulting shaft frequency) but it affects the thrust dedicated to the propeller unit.

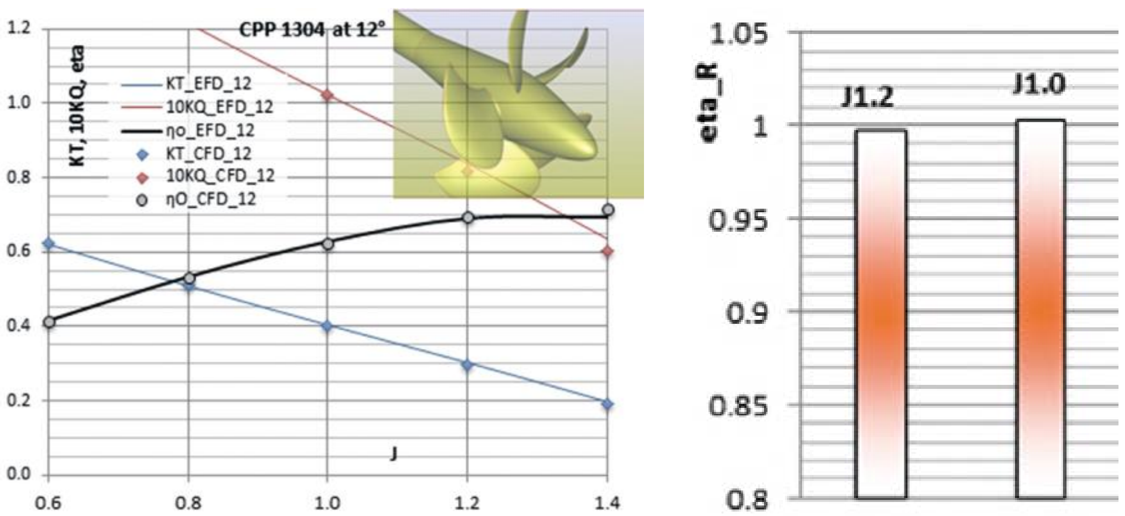


Figure 2: Numerical (CFD) and measured (EFD) performance of propeller CPP 1304 at 12° inclination on the left, numerical values for η_R from CFD results at 12° and 0° (=open water) on the right.

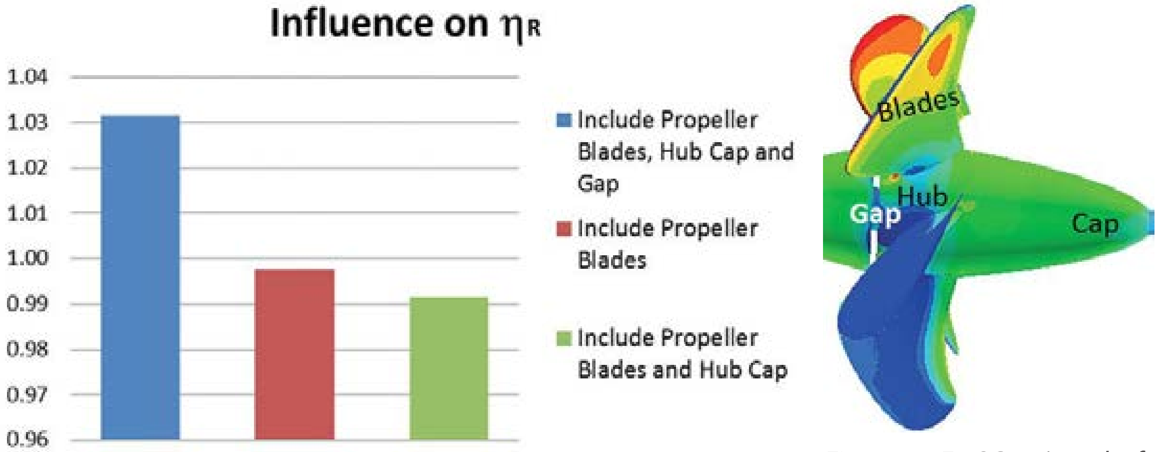


Figure 3: ,FreSCo +' results for η_R from a setup with gap showing the dependence of the accommodation of thrust (DTMB 5415 / CPP 1304, Model-Scale, outward turning propellers, n=12.10 [1/s], Fn=0.41).

Table 1: Rudder acting on the 'small figures' (11 kn case)

	eta0	etaR	w_eff	t
w/o	0.5	**0.997**	0.372	0.242
with Rudd.	0.476	**1.015**	0.416	0.251
Diff. [%]	**-4.8%**	**1.8%**	**11.8%**	**3.7%**

Table 2: Comparing 'Non-Slip Wall' / ,Slip Wall'

	eta0	etaR	w_eff	t
Non-SW	0.5	**0.997**	0.372	0.242
SW	0.555	**1.019**	0.379	0.242
Diff. [%]	**11.0%**	**2.2%**	**1.9%**	**0.0%**

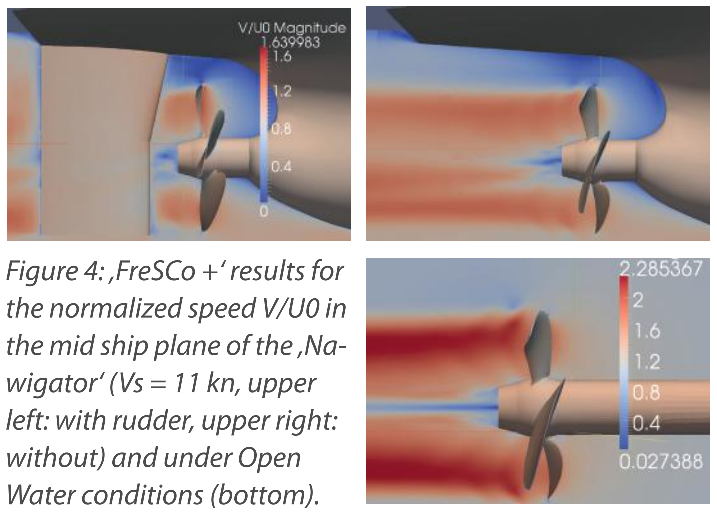


Figure 4: ,FreSCo +' results for the normalized speed V/U0 in the mid ship plane of the ,Nawigator' (Vs = 11 kn, upper left: with rudder, upper right: without) and under Open Water conditions (bottom).

Single Screw Case

The Polish Research-Vessel 'Nawigator XXI' served to study the influence of the rudder on thrust and torque at the propeller. Figure 4 visualizes the situations treated. The lower plot shows, that the numerical open water setup represents a ,reversed mode'. The hub is extended upstream by a long cylinder which is given a 'Slip Wall' boundary condition. For the assessment of η_R an ,orientation effect' is thus excluded. The ,small figures' resulting in this case are shown in Table 1 (various η, wake fraction w and thrust deduction t). Adding the rudder invokes a considerable offset for all ,small figures', the change of η_R (1.8%) even representing the lowest alteration.

In the single screw case, the idea was pursued to implement an alternative computation of η_R by assigning 'Slip Wall' to surfaces linked to the propeller. Thrusts and, above all, moments would change, but ideally for open water and propulsion mode in the same way, so that η_R would remain unaffected. Confining to the case without rudder Table 2 compares 'Slip-Wall' (SW) -results to the values from Table 1, the latter related to the usual 'Non-Slip Wall' (Non-SW) treatment of the propeller. The change of η_R caused by the 'Slip Wall' condition is still 2.2%. ▶

Conclusion

It is always a challenge to interpret and scale results on propulsion tests. Focusing on the propeller it is helpful to build up a correlation between propulsion mode and open water mode. With the 'quality of arrangement' – the latter reflecting the German name for η_R – a related power ratio under identity of thrust and RPM is set up. The INRETRO-project suggests that the substitution ‚influence' for 'quality' is justified. Changes of the ‚arrangement details' surely can invoke alterations in η_R. In many cases advantages in η_R will not indicate true power gain and may be neutralized by alterations of other 'small figures'.

Acknowledgement

This work is linked to the INRETRO project realised as a European ERA-NET venture in the MARTEC framework. The financial funding by the German national association (Bundesministerium für Wirtschaft und Energie) is gratefully acknowledged.

Contact: streckwall@hsva.de

Member of staff
Jan Lassen

Jan Lassen joined HSVA in March 2013 as a project manager in the Manoeuvring & Seakeeping department. Since then he has been in charge of many model test projects for various types of vessels.

Jan is fond of unconventional projects and their challenges, his mind being a perpetual idea factory. In 2015 he reinforced the Resistance & Propulsion department for a period of parental leave and gained strong knowledge on self-propulsion tests, evaluation procedures and power prediction methods. Jan Lassen studied Naval Architecture and Ocean Engineering at the Technical University of Berlin. Within his studies he focused on hydrodynamics and numerical methods. In his spare time Jan enjoys taking his family out on the water sailing the Baltic Sea.