# AMT'13

## The 3rd International Conference on Advanced Model Measurement Technology for the EU Maritime Industry



AMT'13 (*Advanced Model Measurement Technology for the EU Maritime Industry*) is a 2 day international conference with 37 presentations on contemporary experimentation topics in the marine environment. The topics include: PIV and other optical measurement applications; underwater noise measurements; coating performance and drag reduction measurements; various sensors and control applications; pod propulsor measurements; cavitation erosion; smart free running and other tank test applications as well as experimental uncertainty analysis techniques.

The conference will endorse the newly established Hydro-Testing Forum (HTF) as the longer lasting continuation of the FP6–Hydro Testing Alliance (HTA) Network of Excellence which was successfully completed by the end of 2011. There will be a specific emphasis on the topic of underwater noise measurements as response to recently increased awareness of the marine community on the noise pollution of world's seas.

The AMT'13 provides a platform for networking between the conference participants and members of HTF who initiated this conference which is jointly organised and hosted by Newcastle University & CTO S.A. in Gdansk, Poland.

*"The AMT'13 conference represents an opportunity for industry and test facilities, for researchers and academics to learn more about Europe's experimental research capabilities for maritime constructions..."*

SONIC

Achieve QUieter Oceans

CTO S.A.

Newcastle University

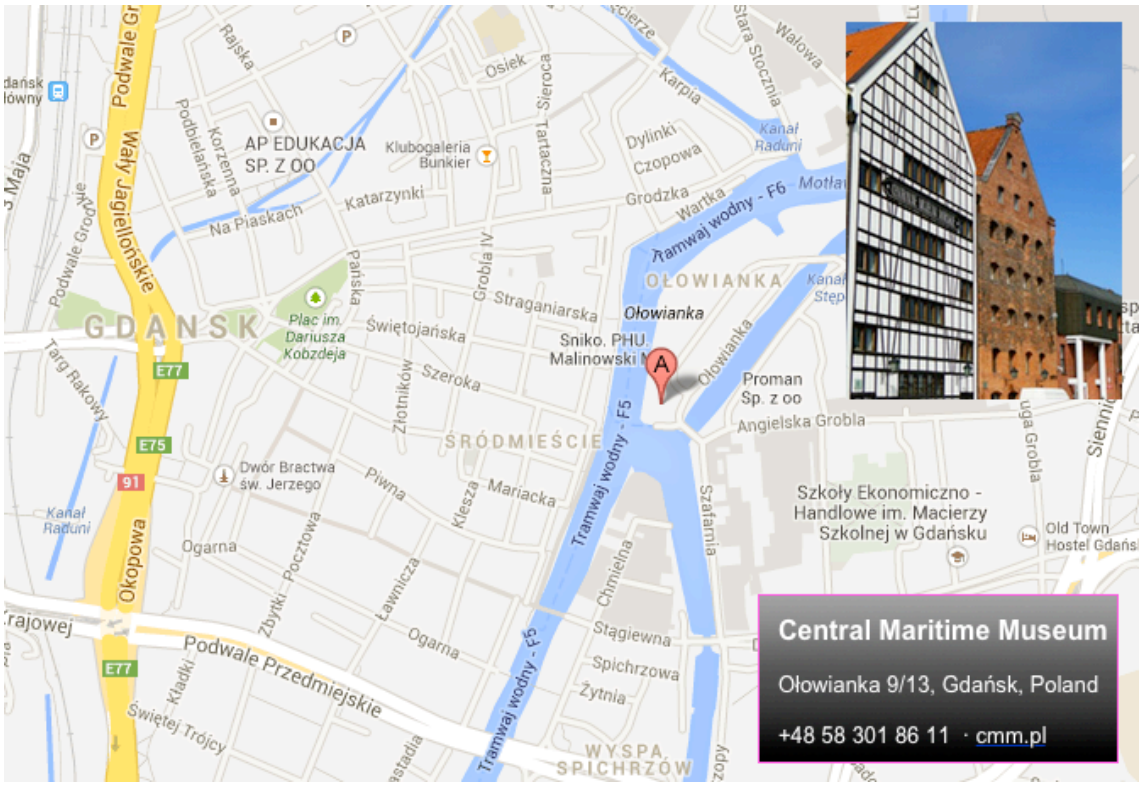
This project is supported by the HydroTesting Forum (HTF)

## Contents



## Date & Venue

The 3rd International Conference on Advanced Model Measurement Technology For the EU Maritime Industry will be held from Tuesday 17th to Wednesday 18th September 2013 at Central Maritime Museum of Gdansk, Poland. Session A of the conference is in "Spichlerze" (The Granaries) at the Museum (9-13 Ołowianka street) and Session B is located on the historical vessel "Soldek" (next to the museum). The dinner will be held at the restaurant "Cala Naprzod" on the 4th floor of Maritime Culture Centre (21/25 Tokarska street).



# Preface

This booklet contains the *Conference Programme* and *Abstracts* of the papers to be presented in AMT'13 conference (*Advanced Model Measurement Technology for the EU Maritime Industry*) as well as other relevant conference details.

The 1st and 2nd of the AMT conference series (AMT'09 and AMT'13) were held at Nantes Tyne in 2009 and at Newcastle upon Tyne in 2011, respectively, as part of the external dissemination of the Hydro Testing Alliance (HTA) Network of Excellence (NoE) which was sponsored under the umbrella of the 6th EU Framework Programme (FP).

Both AMT'09 and 13 were excellent platforms to introduce the activities of HTA to the conference delegates outside the NoE and to share the HTA knowledge gained in the field of model measurement technologies in marine environment. Both conference proceedings are freely accessible in the official site of the Hydro Testing Forum website http://www.hta-forum.eu/

The five year period for HTA-NoE was successfully ended in September 2011 by leaving the AMT Conference Series as its legacy. In the meantime one of the main objectives of HTA project was that the HTA-NoE should become a formal and long lasting forum beyond September 2011. This would in turn sustain the continuation of the AMT conference series.

We are pleased to inform you that HTA phased in 2012 from a Network of Excellence (NoE) to a longer lasting *"Hydro Testing Forum"* (HTF) to sustain its activities.

In HTF maritime research institutes, measurement equipment providers and universities share their experiences in measurement technologies. Experts of the members meet in Forum events through workshops on specific subjects and plenary discussions on new ideas and achievements.

The vision of HTF is to achieve reliable and validated hydro-testing services with advanced measurement techniques for the maritime technologies. The mission of HTF is to be a formal and lasting international network to co-ordinate the definition and introduction of novel measurement, observation and analysis technologies for hydrodynamic model testing environment. Any interesting topic can be agreed as *Community of Practice (CoP)* and investigated by interested HTF members based on the agreement. Membership of the HTF network is open to hydro-testing organisations, universities, measurement systems providers and end-users. To become a member of the HTF network a membership agreement has to be signed.

The Forum meets 3 times per two years with one of the events in connection to the bi-annual AMT Conference. The Forum's plenary meetings are open to all interested parties, under the condition that after a year such 'guest parties' shall decide to become member of the Hydro Testing Forum. The Forum events are hosted by one of the participating organisations.

The topics of AMT'13 are driven by current interests in marine measurements to be presented by 37 technical papers on particular sessions to include: PIV and other optical measurement applications; underwater noise measurements; coating performance and drag reduction measurements; various sensors and control applications; pod propulsor measurements; cavitation erosion; smart free running and other tank test applications as well as experimental uncertainty analysis techniques.

There is a special emphasis on underwater noise measurements due to increasing awareness of the international marine community in relation to increasing noise pollution levels of world's oceans. This is addressed at AMT'13 by a keynote speech and a special session dedicated to two new EU-FP7 collaborative projects (SONIC and AQUO) involving underwater noise as well as other papers on the dedicated noise measurement facilities.

Similar to the previous AMT Conferences AMT'13 Conference Proceedings will be freely available at the HTF website.

We wish you a fruitful conference and an enjoyable staying in Gdansk

**AMT'13 Conference Chair**

**Prof Mehmet Atlar (Newcastle University)**
**Dr Leszek Wilczynski (CTO)**

## Organising Committee

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|---|---|
| Prof. Mehmet Atlar, | University of Newcastle, U.K. |
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| Dr. Rod Sampson | University of Newcastle, U.K. |

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| Mr Lars Gustafsson | SSPA |
| Dr Rene Delfos | TU Delft |
| Mr Ikka Saisto | VTT |

# Conference Programme

# Conference Programme

| Day 1 | 17th September |
|---|---|
| 8:00-9:00 | Registry and Coffee |
| 9:00-9:30 | Opening Ceremony |
| 9:30-10:15 | Plenary Session - Hydroacoustic noise measurements<br>Prof E. Kozaczka<br>Gdansk University of Technology & Polish Naval Academy |
| 10:15-11:00 | Refreshments |
| **Noise Measurements - 1** | **Session A - Spichlerze Room** |
| 11:00-11:25 | **Marine propeller noise measurements techniques in hydroacoustics tunnel**<br>L. Briançon, P. Fournier & D. Frechou<br>DGA Hydrodynamics, France |
| 11:25-11:50 | **Measurement of propeller cavitation noise in the MOERI large cavitation tunnel**<br>H. Seol, C. Park, Y. Park & G. Kim<br>MOERI / KIOST, Korea |
| 11:50-12.15 | **Underwater radiated noise measurements with a silent towing carriage in the Depressurized Wave Basin**<br>J. Bosschers, F.H. Lafeber, A. Bouvy, J. de Boer, R. Bosman & A. Buovy<br>MARIN, The Netherlands |
| 12:15-14:00 | Lunch |
| **EU-FP7 Projects AQUO & SONIC** | **Session A - Spichlerze Room** |
| 14:00-14:25 | **AQUO Project "Achieve QUieter Oceans by shipping noise footprint reduction"**<br>C. Audoly[1], C. Rousset[1], T. Folegot[2], M. Andre[3], L. Benedetti[4], E. Baudin[5] & R. Salinas[6]<br>[1]DCNS Research, France, [2]Quiet-Oceans, France, [3]UPC, Spain, [4]CESA, Belgium, [5]Bureau Veritas, France, [6]TSI, Spain |
| 14:25-14:50 | **EU-FP7 SONIC (Suppression Of underwater Noise Induced Cavitation) project**<br>H. Prins et al<br>MARIN, The Netherlands |
| 14:50-15:15 | **Joint discussion on the AQUO and SONIC projects** |
| 15:15-15:45 | Refreshments |

# Conference Programme

| Day 1 | 17th September 2013 |
|---|---|
| 8:00-9:00 | Registry and Coffee |
| 9:00-9:30 | Opening Ceremony |
| 9:30-10:15 | Plenary Session - Hydroacoustic noise measurements<br>Prof E. Kozaczka<br>Gdansk University of Technology & Polish Naval Academy |
| 10:15-11:00 | Refreshments |
| **PIV Applications - 1** | **Session B - Onboard 'Soldek'** |
| 11:00-11:25 | **PIV measurements of waves and turbulence in stratified horizontal two-phase pipe flow**<br>R. Delfos[1], M. Birvalski[1], M.J. Tummers1 & R. Henkes[1,2]<br>[1]Delft University of Technology, The Netherlands, [2]Shell Projects & Technology, The Netherlands |
| 11:25-11:50 | **PIV measurements of stepped cylinder wakes**<br>J. Visscher[1], I. Teutsch[2] & C. Muthanna[1]<br>[1]MARINTEK, Norway, [2]Brunvoll AS, Norway |
| 11:50-12.15 | **Experimental investigation of the flow around a piggyback cylinder configuration using PIV**<br>P. Levold, C. Muthanna & J. H. Visscher<br>MARINTEK, Norway |
| 12:15-14:00 | Lunch |
| **PIV Applications - 2 & Optical Measurements - 1** | **Session B - Onboard 'Soldek'** |
| 14:00-14:25 | **Applications of particle image velocimetry to complex study of propeller flows**<br>T. Bugalski[1] & A. Reda[2]<br>[1]CTO, Poland & [2]Institute of Hydro-engineering PAS (IBW PAN), Poland |
| 14:25-14:50 | **FPSO's roll damping vortices correlation via PIV visualization in fixed axis decaying and forced oscillation tests**<br>A.C. Fernandes (1), A.R.W. Soares (1) & A.C. Oliveira (2)<br>(1) LOC-COPPE/UFRJ, Rio de Janeiro, Brazil<br>(2) PETROBRAS, Rio de Janeiro, Brazil |
| 14:50-15:15 | **iGPS - Large volume optical measurement system for towing tank**<br>L. Wens<br>C Tech Metrology, Belgium |
| 15:15-15:45 | Refreshments |

# Conference Programme

| Noise Measurements - 2 | Session A - Spichlerze Room |
|---|---|
| 15:45-16:10 | **A multipurpose marine science and technology research vessel for full-scale observations and measurements**<br>M. Atlar, B. Aktas, R. Sampson, I.M. Viola, K.-C. Seo, S. Turkmen & P. Fitzsimmons<br>Newcastle University, UK |
| 16:10-16:35 | **Identification and evaluation of the uncertainties in the current measurement standards, within the framework of AQUO project**<br>[1]R.S. Mullor, [1]A,.M. Rodriguez, [1]P.B. Palomo, [1]C. Rousset, [2]C. Audoly & [3]E. Baudin<br>[1]TSI, Spain, [2]DCNS, France, [3]Bureau Veritas, France |
| 16:35-17:00 | **Noise measurements for studying propagation of harbour noise to residential areas close to ports**<br>P. Zoet, P. Kellett, S. Turkmen & O. Turan<br>University of Strathclyde, UK |
| Day 2 | 18th September |
| 8:00-9:00 | Registry and Coffee |
| **Coating Performance Measurements** | **Session A - Spichlerze Room** |
| 9:00-9:25 | **Flat plate model test for the evaluation of skin friction in the cavitation tunnel**<br>B-G. Paik[1], K-Y. Kim[1], J-H Kim[1], S-R. Cho[1], J-W. Ahn[1], S-R. Cho[2], K-R. Kim[2] & Y-U. Chung[2]<br>[1]MOERI KIOST, Korea. , [2]Daewoo Shipbuilding & Marine Engineering Co. Ltd. |
| 9:25-9:50 | **A multi-purpose flume for evaluation of hull coatings**<br>G. Politis[1], M. Atlar[1] & B. Kidd[2]<br>[1]Newcastle University, UK, [2]International Paint, Felling, UK |
| 9:50-10:15 | **Experimental procedures toward the performance assessment for low frictional marine paints**<br>I. Lee & H-H. Chun<br>Pusan National University, Korea |
| 10:15-11:00 | Refreshments |
| **Friction Drag Reduction Technologies** | **Session A - Spichlerze Room** |
| 11:00-11:25 | **Flat plate drag reduction by air cavities on a ship model**<br>O. Zverkhovskyi[1], R. Delfos[1], J. Westerweel[1] & T. van Terwisga[1,2]<br>[1]Delft University of Technology, the Netherlands, [2]MARIN, The Netherlands |
| 11:25-11:50 | **Local flow measurements with multiphase flows**<br>S. Gokcay & M. Insel<br>Istanbul Technical University, Turkey |

# Conference Programme

| Optical Measurements - 2 & Experimental Uncertainty | Session B - Onboard 'Soldek' |
|---|---|
| 15:45-16:10 | **Optical measurements of free surface for the analysis of ship waves in towing tank**<br>G. Gomit[1], D. Calluaud[1], L. Chatellier[1], L. David[1] & D. Fréchou[2]<br>[1]Université de Poitiers, France, [2]DGA Hydrodynamics, France |
| 16:10-16:35 | **Uncertainty analysis of finite length measurement signals**<br>J. Brouwer, J. Tukker & M. van Rijsbergen<br>MARIN, The Netherlands |
| 16:35-17:00 | **Propagation of experimental uncertainty from force measurements into manoeuvring derivatives**<br>M.D. Woodward<br>Newcastle University, UK |

| Day 2 | 18th of September 2013 |
|---|---|
| 8:00-9:00 | Registry and Coffee |
| **Sensors - 1 & Control Technologies - Conference room 2** | **Session B - Onboard 'Soldek'** |
| 9:00-9:25 | **On strobe light control and dynamic calibration**<br>J. Reemts<br>The Hamburg Ship Model Basin (HSVA), Hamburg, Germany |
| 9:25-9:50 | **Determining the dynamic quality of signal conditioners**<br>E. van de Bunt, A. Bouvy & F. Bloemhof<br>MARIN, The Netherlands |
| 9:50-10:15 | **Design of tidal power monitoring and control system based on CAN bus and LabVIEW**<br>Y. Li, D. Wang & X. Gong<br>Harbin Institute of Technology at Weihai, China |
| 10:15-11:00 | Refreshments |
| **Sensors - 2 & Smart Free Running Tests** | **Session B - Onboard 'Soldek'** |
| 11:00-11:25 | **Dynamically verifying the calibration of pressure transducers**<br>A. Bouvy<br>MARIN, The Netherlands |
| 11:25-11:50 | **Experimental study of the asymmetrical propeller loads occurring in unmanned self-propelled free running surface model tests**<br>S. Mauro<br>CNR-INSEAN, Rome, Italy |

# Conference Programme

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|---|---|
| 11:50-12.15 | **Measurement and impact of surface topology and hydrodynamic drag of fouling control coatings**<br>P. Stenson, B. Kidd & A.A. Finnie<br>International Paint, U.K. |
| 12:15-14:00 | Lunch |
| **Pod Propulsor Measurements** | **Session A - Spichlerze Room** |
| 14:00-14:25 | **Open water performance characteristics of a pod propulsor – the benchmark test**<br>R. Głodowski[1], J. Richards[2], K. Koushan[3], S.A. Alterskjaer[3], M. Atlar[4], & I. Saisto[5]<br>[1]CTO S.A., Poland [2]The Hamburg Ship Model Basin (HSVA), Germany, [3]MARINTEK, Norway, [4]Newcastle University, UK, [5]VTT, Finland |
| 14:25-14:50 | **Numerical predictions of open water performance characteristics of a podded propulsors - extended studies**<br>R. Głodowski[1], I. Saisto[2] & S. Steen[3]<br>[1]CTO S.A., Poland, [2]VTT, Finland, [3]NTNU, Norway |
| 14:50-15:15 | **Prediction of the effect of cavitation on propeller ice interaction**<br>Rod Sampson[1] & Mehmet Atlar[2]<br>[1]King Propulsion, Leesburg VA, USA, [2]Newcastle University, UK |
| 15:15-15:45 | Refreshments |
| **Cavitation Erosion** | **Session A - Spichlerze Room** |
| 15:45-16:10 | **Propeller tip vortex cavitation observation technique by using partial blade Model**<br>H. Lee, S-H. Lee, S-Y. Park, G-H. Choi & B-J. Chang<br>Hyundai Heavy Industry, Korea, Maritime Research Institute, Korea |
| 16:10-16:30 | Closing Ceremony |

# Conference Programme

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|---|---|
| 11:50-12.15 | **Free running model technology for dynamic positioning in an ice model basin**<br>A. Haase & P. Jochmann<br>The Hamburg Ship Model Basin (HSVA), Hamburg, Germany |
| 12:15-14:00 | Lunch |
| **Miscellaneous (smart) tank testing** | **Session B** |
| 14:00-14:25 | **Automatic waterline registration of a ship model in waves**<br>M. T. Ruiz[1], S. Geerts[1],G. Delefortrie[2] & M. Vantorre[1]<br>[1]Ghent University, Belgium, [2]Flanders Hydraulics Research, Belgium |
| 14:25-14:50 | **The influence of a keel bulb on the hydrodynamic performance of a sailing yacht model**<br>K.N. Sfakianaki, D.E. Liarokapis, G.P. Trahanas & G.D. Tzabiras<br>National Technical University of Athens, Greece |
| 14:50-15:15 | **A quasi-steady method for efficiently conducting open water model tests**<br>F.H. Lafeber, J. Brouwer & J. Dang<br>MARIN, The Netherlands |
| 15:15-15:45 | Refreshments |
| | **Session B** |
| 15:45-16:10 | Free |
| 16:10-16:30 | Closing Ceremony |

# List of abstracts

**{session order}**

Plenary Lecture



AMT'13 Technical Papers

# Hydroacoustic Measurements

Prof. E. Kozaczka
Gdansk University of Technology & Polish Naval Academy, Poland

## Abstract

The paper deals mainly with investigation of underwater noise that propagation is in shallow water. In this paper the experimental investigation results concerning the distribution of the sound field pressure generated by moving ships in the shallow water at the small distance from the ship have been presented. The main acoustical characteristics describing features of the field are spectrograms in pseudo 3D system – distance and frequency and sound intensity. Results pointed individual features of ship are known often as an acoustical signature of the ship.

The two main sources of the ship will be taken into account. Vibration energy generated by the mechanisms is transferred through structural elements to surrounding water where it propagates in the form of acoustic waves of broadband frequencies. Also the noise generated by the ship propeller will be matter of interest.

# Marine propulsor noise measurements techniques in hydroacoustics tunnel

L. Briançon, P Fournier & D. Frechou
DGA Hydrodynamics, France

## Abstract

The operational requirements for naval and research vessels has seen an increasing demand for quieter ships either to comply the ship operational requirements or to minimize the influence of shipping noise on marine life. Hence, the management of a ship's radiated noise signature requires better, more reliable estimates of propeller noise, which is one of the major contributor. This task is complicated by several factors: First, the procedure which consists in limiting propeller noise signature to cavitation free operation might not be not sufficient as propeller noise without cavitation becomes a critical issue. Second, the physical phenomena in cavitating and non-cavitating propeller noise are complex and not always well understood. Third, improved noise signature requires designs which differ from conventional practice, and hence there is no way of relying on past experience. Hence, propeller noise management requires reliable tools capable of predicting the acoustic signature in order to specify noise targets, and at the design stage to achieve a ship architecture which is globally compatible with a noise target. DGA Hydrodynamics has developed a procedure to manage propeller noise prediction using a low noise large hydrodynamic tunnel, the GTH, which since its construction has seen continuous improvements in terms of noise, equipment, and test procedure.

This paper presents a review of the experimental capabilities of the tunnel, of the measuring techniques, and of the noise measurement procedure used for propeller noise prediction:
a first recall of the noise signature of a ship and the propeller contribution, the similarity laws to be respected for noise measurement at model scale, the specific constrain on the model propulsion testing, the measurement techniques and procedure used to measure the radiated noise of marine propeller with and without cavitation, some examples of propeller noise measurements.

# Measurement of propeller cavitation noise in the MOERI large cavitation tunnel

H. Seol, C. Park, Y. Park & G. Kim
MOERI / KIOST, Korea

## Abstract

In recent decades, levels of noise in marine environment have been increased. Marine mammals and fishes are sensitive to sound. Commercial vessel is one of the most important sources of underwater noise pollution. Cavitation of a marine propeller is the most prevalent source of underwater noise and it is often the dominant noise source of a marine vessel. Therefore, it is important to be able to predict and to reduce a cavitation noise at the ship design stage.

In this paper, some research and development results on a propeller cavitation noise will be described. The propeller cavitation noise measurement tests are carried out with a model hull and a propeller in the MOERI Large Cavitation Tunnel (LCT). Propeller generated noise data are acquired using hydrophones installed at the various positions and measurement equipment. The noise levels of the model propeller are scaled to full-scale results using the scale law recommended by the 18$^{th}$ ITTC Cavitation Committee. Finally, the model test results and scaling results are analyzed and discussed.

# Underwater radiated noise measurements with a silent towing carriage in the Depressurized Wave Basin

J. Bosschers, F.H. Lafeber, A. Bouvy, J. de Boer, R. Bosman & A. Bouvy
MARIN, The Netherlands

## Abstract

Because of the increasing interest in underwater radiated noise levels of ships, noise mitigation measures have been applied to the new secondary towing carriage of the Depressurized Wave Basin (formerly known as the Depressurized Towing Tank). This paper presents the noise levels of the towing carriage that have been achieved and discusses some aspects of radiated noise measurements in a towing basin. It is shown that the carriage can be applied for the measurement of propeller cavitation noise. The noise levels of the new carriage are compared to the noise levels of a silent towing carriage developed specifically for a project related to surface ship flow noise.

# PIV measurements of waves and turbulence in stratified horizontal two-phase pipe flow

R. Delfos[1], M. Birvalski[1], M.J. Tummers[1] & R. Henkes[1,2]
[1]Delft University of Technology, The Netherlands,
[2]Shell Projects & Technology, The Netherlands

## Abstract

Fully-developed stratified two-phase pipe flow of air and water is studied in an experimental setup comprising of a horizontal transparent pipe of 50 mm diameter with the goal of obtaining detailed velocity measurements and wave characteristics in the flowing liquid layer.

A dual camera technique was developed by combining planar PIV and profile capturing to obtain the velocity field below the moving interface. Depending on the flow rates of water and air, the liquid layer can be laminar or turbulent, and the interface can be smooth (quiescent) or wavy. Conditional averaging relative to the wave phase was applied in order to decompose the velocity field into three components: time-averaged mean velocity profile, a wave-induced velocity field and turbulent fluctuations. In this way, an attempt was made to separate the fluctuations in the flow due to the waves from those due to the turbulence.

Detailed interface statistics and phase-averaged velocity fields were obtained for laminar and turbulent wavy cases. The waves are shown to be asymmetric with gravitational and capillary forces of similar magnitude at larger gas flow rates. Linear wave theory provides a good approximation of the wave-induced velocity profile, except in regions close to the interface where the wave non-linearity causes a deviation. The complete separation of wavy and turbulent motion was not possible due to the non-linear interaction of waves and turbulence. An extended version of this paper is submitted to the International Journal of Multiphase Flows.

# PIV measurements of stepped cylinder wakes

Jan Visscher[1], I. Teutsch[2] & C. Muthanna[1]
[1]MARINTEK, Norway, [2]Brunvoll AS, Norway

## Abstract

Subject of the present study is the investigation of the wake behind circular stepped cylinders. Experiments were performed using Particle Image Velocimetry (PIV). Cylinder models with diameter ratios D/d=1, D/d=6/5 and D/d=2 were investigated at Reynolds numbers $Re_D$=2244, $Re_D$=12821 and $Re_D$=51282. The influences of step size and Reynolds number on the wake flow features were of major interest. Vortex development in the wake was investigated by analyzing mean flow fields and time series. Distinct vortex shedding cells were found from spectral analysis. It was observed that an increase in $Re_D$ led to a decrease in eddy formation length $L_f$. An increase in diameter ratio caused the development of a large and a small diameter wake with distinct eddy formation lengths $L_{f,L}$ and $L_{f,S}$ . Due to the mismatch in vortex shedding frequencies in the two wakes, vortices came out of phase and connected to subsequent vortices on the same side of the step. This occurred more frequently at higher diameter ratios. Several vortex shedding cells were identified in the wake of the step cylinders, their number increasing with step size and differing for different Reynolds numbers.

# Experimental investigation of the flow around a piggyback cylinder configuration using PIV

P. Levold, C. Muthanna & J. H. Visscher
MARINTEK, Norway

## Abstract

The flow behind a piggyback cylinder has been investigated. A diameter ratio of d/D = 0.417 has been used with the small cylinder located straight above the large cylinder. Experiments have been conducted with gap ratios ranging from 0.002 to 0.8 and Re between $2.09 \cdot 10^3$ and $3.59 \cdot 10^4$. Initial observations show that the flow is dependent on the gap ratio between the two cylinders. If the gap between the two cylinders in small enough, the flow in the wake acts similar to the flow behind a cylinder of an equivalent diameter. For large gap ratios the wake is gradually turning into two independent wakes, one behind each cylinder. Further observations show that the amount of interaction of the wakes behind the cylinders depends on the free stream velocity and, as the velocity increases, the gap ratio necessary for two wakes to form increases. The results show that PIV was well suited to providing a better insight to such configurations.

# AQUO Project
# "Achieve QUieter Oceans by shipping noise footprint reduction"

C. Audoly[1], C. Rousset[1], T. Folegot[2], M. Andre[3], L. Benedetti[4], E. Baudin[5] & R. Salinas[6]
[1]DCNS Research, France, [2]Quiet-Oceans, France, [3]UPC, Spain, [4]CESA, Belgium, [5]Bureau Veritas, France, [6]TSI, Spain

## Abstract

The need to mitigate underwater noise footprint due to shipping and to prevent potential adverse impacts on marine life is now of increasing interest to scientists and policy makers. To address this issue, the project AQUO "Achieve QUieter Oceans by shipping noise footprint reduction" (www.aquo.eu) started in October 2012 for 3 years. The AQUO project was built in the scope of FP7 European Research Framework. The final goal of AQUO project is to provide to policy makers practical guidelines, acceptable by shipyards and ship owners. Two types of solutions taking into account bioacoustics criteria will be provided: solutions regarding ship design (including propeller and cavitation noise) and solutions related to shipping control and regulation. The project is supported by relevant methods and tools (noise footprint assessment tool, dedicated bio-acoustic studies, in-situ measurements at sea, scale model experiments, existing database, etc.). These tools will be used to assess the effectiveness of noise mitigation measures in order to select the most appropriate.

In a first part, this paper presents a general overview of the project. In a second part, the main outputs of the first year of the project are given: review of the needs by establishing a map where noise sensitive areas for marine fauna figure together with maritime traffic overview, list of ships to be tested, derivation of ship underwater radiated noise (URN) patterns along frequency, where the global radiated noise of a ship as a source will be split into different noise components and the search for bioacoustic criteria relevant to representative marine species of European areas.

# EU-FP7 SONIC
# (Suppression Of underwater Noise Induced Cavitation) project

H. Prins et al
MARIN, The Netherlands

## Abstract

The aim of the SONIC project is to develop tools to investigate and mitigate the effects of underwater noise generated by shipping, both in terms of the footprint of an individual ship (a "noise footprint") and of the spatial distribution of sound from a large number of ships contribution to the sound (a "noise map"). The project`s first objective is to enhance the understanding of noise generated by a cavitating ship propeller. The second objective is to validate predictions of noise levels for individual ships, and to classify ships based on simplified noise models. SONIC's third objective is to map the noise generated by shipping in general and to propose mitigation measures for quietening the oceans.

The EU has set out on improving the environment within its member states by adopting the Good Environmental Status. This has been further defined in the Marine Strategy Framework Directive, in which it describes descriptors for measuring the environmental status. One of these descriptors is the underwater noise linked to among others maritime transport. It is stated that the reduction of underwater noise will be a measure for the improvement of the environment. SONIC will deliver the technical knowledge required for mapping, measuring and mitigating noise from shipping. The results of the SONIC project will contribute to quieting the oceans and improving the well-being of marine life.

The SONIC consortium consists of world-leading hydrodynamic institutes, noise experts, propeller designers, reputable universities with specialised centres in this field, major European shipyards, and a class society; bringing together a wealth of knowledge on propeller cavitation and noise reduction. Interaction with the marine biology network has been established by obtaining necessary input to the project from renowned institutes in the field of marine biology. Furthermore, the consortium will aim for an open Advisory Board, consisting of a wide range of experts from the marine and maritime research communities, including members of the MARCOM+ forum.

The SONIC project will be executed in close co-operation with the AQUO project, by sharing data, organising combined workshops and dissemination activities, and by joining forces on developing guidelines for industry and regulations. This presentation will give an overview of the project's objective and strategy. In other presentations, SONIC partners will describe their initial work.

# Applications of particle image velocimetry to complex study of propeller flows

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## Abstract

Particle Image Velocimetry (PIV) has a rapid development and is now a reliable experimental technique for naval research applications. This technique could be implemented in towing tanks and cavitation tunnels for the complex study of propeller flows. The paper will describe applications of the 2D PIV tests performed in the cavitation tunnel of Ship Design and Research Centre, Ship Hydromechanics Division, Gdansk. The goal of the tests was to measure and visualize a velocity field about propeller working in presence of the model mounted inside the cavitation tunnel. The object of the tests was a DB model ("dummy body") of an aft part "Nawigator XXI" vessel. The model was mounted in the test section of the cavitation tunnel in CTO S.A. The measurements were taken in two different planes: horizontal and vertical. For both laser plane positions there was 13 rectangle measuring planes. Distance space between them was 20 mm in horizontal position and 10 mm in vertical position. The laser head and the camera were mounted outside the test section. The flow speed in the test section was about 3-4 m/s.

The potentials for validation of CFD calculations will be also discussed. Future CTO plans for further applications of the PIV system will be introduced.

# FPSO's roll damping vortices correlation via PIV visualization in fixed axis decaying and forced oscillation tests

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## Abstract

The control of the roll motion of any boat is a very relevant task. The simplest and economical way to damp this motion is through the use of bilge keels. The present work aims to optimize this device studying dimensions and shapes. The work address the use of strake shape (helical) for the bilge keel, what was never been studied before. By vary the angle of a flat bilge keel with respect to the hull the work also investigates if there is an optimum angle beyond the 450 that dissipates higher energy. These investigations passes through the discussion of the use of decay test performed about a fixed the axis about the center of roll. It also performed forced oscillations tests for comparisons with the decay tests. Simultaneously the PIV (Particle Image Velocimeter) has been used, to get the streamlines evolution via a laser flashing and high speed cameras. The resultant behavior of the hull is then justified by specific the vortex patterns generated by the bilge keels. The behavior of these vortices is far from being well understood. The work proposes advances both in the measurements and tests (for instance, a pure moment device has been used in some forced oscillation) and in the synthesis to get the damping coefficients.

# iGPS - Large volume optical measurement system for towing tank

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## Abstract

The iGPS system is a large volume measurement system made by Nikon Metrology. It is a scalable metrology system that mimics the functionality of a GPS system. The system can be used for large volume dimensional verifications and also has dynamic measurement capabilities. The working principle of the system is reviewed as well as its performance. The different aspects of deploying such a system in a towing tank are discussed.

# A multipurpose marine science and technology research vessel for full-scale observations and measurements

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& P. Fitzsimmons,
Newcastle University, UK

## Abstract

In order to support the marine research, teaching and consultancy activities in the North East region of England, Newcastle University has recently replaced their aged, slow-speed mono-hull research vessel with a modern and relatively high-speed modern catamaran, "The Princess Royal".

In order to support the marine research, teaching and consultancy activities in the North East region of England, Newcastle University recently replaced their aged, slow-speed mono-hull research vessel with a modern and relatively high-speed catamaran "The Princess Royal". The hullform of the new research vessel was designed by the School of Marine Science and Technology staff and student. This was based on the catamaran application of the displacement type Deep-V hull forms with a novel anti-slamming bulbous bow and tunnel stern. The vessel was built in aluminium alloy and locally by a North East yard.

The Princess Royal lends itself to be used as a multi-purpose science and technology platform with a flexible speed range for a wide variety of full-scale marine measurements and observations. Her main duties include conventional trawling, sampling, dredging, marine wild life observation, wind farm/renewable device support, performance monitoring, coating/fouling inspection, cavitation and noise research. She is equipped with a moon pool facility for ROV deployment and complemented by a wide range of hydraulic cranes and hydrographic winch. The propeller shaft fitted with a load cell to measure thrust, torque and shaft bending moment. Motion sensor combined with vertical wave radar, EM speed log, propeller observation windows, borescope apertures, hydrophone facilities and wide array of marine science equipment further complements the vessel on board.

This paper reviews the mission profile and various technical details of the Princess Royal. Recent operational experiences with her through various research, teaching and industrial activities are also highlighted since her entry into the service by the end of 2011.

# Identification and evaluation of the uncertainties in the current measurement standards, within the framework of AQUO project

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## Abstract

The acoustic impact of ships on the underwater environment has gained a growing attention during the last years. As a consequence, important efforts are being applied to develop techniques to evaluate it. Three factors are important to have properly estimated to obtain a correct evaluation of the ship impact on marine fauna: the source level of the ship, the losses through the environment and the sensitivity of the receptor.

This paper is focused on the first factor. Having a correct estimation of the source level of each ship is vitally important not only for assessing the impact on marine fauna but also to evaluate the efficiency of the different solutions applied to reduce the underwater radiated noise of the ship and for correct comparison with the currents and forthcoming URN limits. Current measurement standards and devices in use for civil applications have numerous and important technical deficiencies and drawbacks such as their frequency range, the conditions that the measurement location must meet or the lack of repeatability due to many factors being out of control during the measurement. Most of these drawbacks generate uncertainties that limit the accuracy of any posterior model to estimate the noise level in different sea regions and make difficult the comparison between two measurements taken in different places or at different times, that is to say the repeatability.

To attend these worries, thanks to the previous experience of the authors as vibro-acoustic designers of the most relevant silent vessels of the European fleet and their participation in the BESST and SILENV project as leader of the on-site measurement campaign, a deep revision of the current measurement standards and devices in use are being done within the framework of the AQUO project. The main sources of uncertainties regarding the device, the medium, the vessel and the posterior processing data, will be identified and analysed to estimate the variability associated to each measurement and to identify which technical deficiencies are most important to solve.

# Noise measurements for studying propagation of harbour noise to residential areas close to ports

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## Abstract

In the study, two sets of full scale harbour noise measurements were carried out close to port areas. Aim of the measurements was to identify the contributions from different sources, establish the propagation mechanisms and to evaluate measurement results through the current local and European noise regulations. Noise characteristics were recorded at the source and at a variety of receiver locations concurrently. This allowed for the propagation of the noise, and in particular the peak measurements to be fully mapped. These results were compared to predicted sound pressure levels at the receiver calculated using existing formulations. These existing formulations include simple geometrical spreading laws, as well as formulae which also account for atmospheric absorption and other causes of sound attenuation. This gave rise to a study of the differences in propagation as a result of variations in harbour and surrounding area geography, as a means of explaining the uncertainties.

# Optical measurements of free surface for the analysis of ship waves in towing tank

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## Abstract

This study focuses on the development of optical methods for the measurement of free surfaces and their applications to the measurement of waves generated by a ship model in a towing tank. Two methods have been investigated. The first method is based on a stereo vision system and on the cross-correlation of images. The second is based on the theory of light refraction and on the analysis of the apparent displacement between a reference and refracted images of a laser sheet through the surface. These two methods are applied to the measurement of the wave field of a model ship for various Froude numbers. These measurements allow the reconstruction of the wave pattern around the model ship. Therefore, the main characteristics of the wake and their dependence to the Froude number can be studied.

# Uncertainty analysis of finite length measurement signals

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## Abstract

The finite length of a towing tank induces a random uncertainty in the mean value of a measurement signal. This uncertainty is not negligible if the signal contains low frequency components with large amplitudes, such as the towing force on a ship model. Ideally, the random uncertainty of towing test results is determined by repeat or reproduction tests. Though scientifically correct, in commercial research this is not always viable.

An alternative is to obtain an estimate of the uncertainty of the mean value by signal analysis of a single measurement. An analytical solution for the standard deviation of the mean of a band pass noise process is derived. Depending on the bandwidth and lowest frequency of the process, the standard deviation of the mean decays either linearly or with the square root of the inverse of the measurement time as long as the measurement time exceeds a certain threshold. This agrees with the solution obtained from sample statistics for respectively a special class of correlated samples and fully uncorrelated samples.

Two methods to estimate the random uncertainty of the mean from a single finite length sample record are derived. One method uses the calculation of the autocovariance function. The other uses the division of a signal into equally-sized segments. Both methods are verified using the analytical solution for a band pass noise process. Finally, the methods are applied to the towing force signal of a ship model.

# Propagation of experimental uncertainty from force measurements into manoeuvring derivatives

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## Abstract

Many engineering problems require the prediction of motion performance through time-domain simulation based on force coefficients obtained by experiment. Procedures for obtaining the experimental uncertainty in the force measurements are typically given by the relevant national metrology institutions. However, the propagation of uncertainty from force measurements through to the predicted coefficients (or derivatives) and onward into motion performance predictions, is less well defined. Using ship manoeuvring-performance as case study, this paper provides a method for calculating the uncertainty in the predicted motion derivatives, in terms of the uncertainty in the contributing force measurements. In so doing, the paper identifies a likely source of the scatter found in performance prediction. The findings are fundamental to numerical modelling, (rather than ship performance prediction), highlighting as they do, an inherent and unavoidable weakness when modelling of non-linear systems.

# Flat plate model test for the evaluation of skin friction in the cavitation tunnel

B-G. Paik[1], K-Y. Kim[1], J-H. Kim[1], S-R. Cho[1], J-W. Ahn[1], S-R. Cho[2], K-R. Kim[2] & Y-U. Chung[2]
[1]MOERI KIOST, Korea, [2]Daewoo Shipbuilding & Marine Engineering Co. Ltd.

## Abstract

In the present study, the flat plate model test method is developed to evaluate the skin friction of the marine coating or treated-surface in the cavitation tunnel. Six-component force balance is used to measure the profile drag of the flat plate and strut. LDV(laser Doppler velocimetry) )technique is also employed to evaluate the drag and to figure out the reason of the drag reduction. The flow velocities above the surface can be used to assess the skin friction, combined with direct force measurement. Since the vortical structure in the coherent turbulence structure influences on the skin friction in high Reynolds number regime, the interaction between the turbulence structure and the surface wall is paying more attention. This sort of thing is important in the passive control of the turbulent boundary layer because the skin friction can't be determined only by wall condition. As complicated flow phenomena exist around a paint film or a treated-surface, systematic measurement and consideration are necessary to evaluate the skin friction appropriately.

# A multi-purpose flume for evaluation of hull coatings

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[1]Newcastle University, UK, [2]International Paint, Felling, UK

## Abstract

Following the presentation of Newcastle University's new flowcell facility in AMT'09 and the presentation of the first aging/polishing rate flume design in AMT'11 the paper presents a combined facility that integrates the above two devices into one robust hull coating efficiency measurement device. This new device is designed for long exposure of the coated surfaces in realistic sea water flow conditions to cater for the aging or polishing of mainly Self-Polishing Copolymer coatings. The main feature of this facility is that the testing section is divided into two sections, the first that is mainly used for skin friction measurements as well as aging of Self Polishing Copolymers and the second that is used for aging only. The device is also suitable for adhesion strength experiments on coated surfaces covered with microfouling hence evaluating the antifouling performance of foul release coatings. The main advantage of this flume is that the flow can directly be related to the flow around ship's underwater hull. A standardized testing plate has been designed which is used in this facility and is also used in the new high speed insert fitted in the Emerson Cavitation Tunnel for the performance of boundary layer experiments. This plate is also used for fouling growth in static and dynamic conditions as well as all surface roughness measurements. Overall those developments combined with the new multipurpose flume, presented in the paper, constitute a great tool for the evaluation of antifouling coatings in a holistic manner contributing to smoother ship hulls.

# Experimental procedures toward the performance assessment for low frictional marine paints

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## Abstract

In this study, the laboratory standard procedures for the performance evaluation of low frictional marine paints are proposed. With the increasing oil price and dropping shipping charges, the improvement of energy efficiency has now become a significant concern for worldwide ship operators. In addition, the later phases of EEDI (Energy Efficiency Design Index) with more stringent energy efficiency requirement urge the implementation of energy saving technologies which have never been considered before. Among various technologies for the improvement of resistance and propulsion efficiency, the low frictional AF(Anti-Fouling) paint has become appealing in many aspects. Thus, several low frictional AF paints are being released in market. The resistance performances of those products have, however, been investigated through laboratory tests conducted mainly by the manufacturers themselves. Furthermore, the experimental methods involved are so varied that the comparison of such performances are quite difficult. With a view to establishing a standard procedure, results from different lab tests are compared. The experimental methods considered in this study are flat-plate resistance measurement in towing tank, torque measurement in rotor tester and shear force measurement from flush-mounted floating plate balance in a high-speed circulating water tunnel. A few low frictional AF(Anti-Fouling) paints have been tested using these methods and the comparative resistance performance will be presented.

# On strobe light control and dynamic calibration

J. Reemts
The Hamburg Ship Model Basin (HSVA), Hamburg, Germany

## Abstract

During the last year two hardware components were developed at HSVA's Propeller and Cavitation department in order to improve cavitation observation techniques. Pressure transducers are usually calibrated by means of a static pressure calibrator. However, the pressure fluctuation at the ship hull produced by a rotating propeller is a dynamic signal with low amplitude. In order to check the dynamic behavior of pressure transducers, as well as the complete measurement tool chain, a dynamic pressure calibrator was designed. It creates periodically pressure pulses of defined amplitudes for up to 16 pressure transducers simultaneously. A synchronized synthetic speed signal simulates a propeller shaft encoder signal which allows for a connection with HSVA's standard pressure pulse evaluation hard- and software. Additionally a new stroboscope controller was developed in order to replace different existing solutions at HSVA's test facilities with one configurable system. The system is based on a standard RISC-Microcontroller running at 15 MHz. A simple configuration menu allows for adaption to different shaft encoder configurations and resolutions as well as setting of relevant propeller properties. One of the nicest features of the stroboscope controller is a bluetooth remote control option which supports Android smartphones running the HSVA StrobeControl App. Buttons on the touch screen are used for remote control of all functions. This feature allows the user to observe the propeller from any perspective with full control in one hand.

# Determining the dynamic quality of signal conditioners

E. van de Bunt, A. Bouvy & F. Bloemhof
MARIN, The Netherlands

## Abstract

This paper will describe a method to determine the quality of a signal conditioner over the conditioners bandwidth. An analogue signal conditioner can be specified by its accuracy, linearity or other static values (so called DC specifications). But when you are to measure dynamic signals in general, it is more straightforward to pay attention to the AC specifications. These AC specifications like “Effective Number of Bits” (ENOB) are usually not available in the conditioners specification. This paper will present both a time domain approach and an approach using the spectral domain to determine the ENOB. Both approaches have their advantages and are used simultaneously in the process of determining the dynamic quality of a signal conditioner. The combined approaches will also deliver information on noise levels and harmonic distortion and will give insight in the general dynamic behaviour and quality of the signal conditioner.

The ENOB value can be determined for a conditioners analogue signal input range and for a conditioners strain gage input range using a special designed Wheatstone bridge simulator. The method is applied to typical signal conditioners of five different suppliers of signal conditioners. The results will be discussed without revealing the suppliers name. The ENOB value will be related to the transducer accuracy. The paper will outline the different steps in the method and will review the limitations of the method.

# Design of tidal power monitoring and control system based on CAN bus and LabVIEW

Y. Li, D. Wang & X. Gong
Harbin Institute of Technology at Weihai, China

## Abstract

In order to get the measured data of tidal power generator undersea and realize controlling of executive parts, the monitoring and control system for tidal power device is designed. In this system hardware designation, STC89C52 is used as microcontroller and CAN bus is used as key technology; and in software designation, C language is utilized as MCU programming language and graphical language of LabVIEW is utilized as PC interface programming language. Finally, using CAN bus to transfer data at the bit rate of 100Kbps in a distance of 500 meters between control room on land and generating device underwater, the data is transmitted to host computer and control cabinet with variable-speed control method via RS232 bus respectively; taking high reliability and stability of tidal power system into account, the real-time control of brake, clutch, water pump inside the generating device is achieved in order to ensure the normal operation of system. The data transmission, executive components real-time control and interface display are ultimately completed through both hardware and software designation.

# Flat plate drag reduction by air cavities

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## Abstract

*This paper describes the experimental study on the frictional drag reduction on a horizontal flat plate by an air cavity. The integral shear force on the plate was measured in a cavitation tunnel by a custom built force balance. First, the friction was measured on a conventional flat plate. Then, the measurements were done with the developed air cavity on the test plate. The results of the comparison showed a possibility to reduce the friction drag on the test plate up to 60%.*

# Local flow measurements with multiphase flows

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## Abstract

Numerous research attempts for reduction of ship viscous resistance have been attempted by boundary layer modification with the utilization of both active and passive methods. Experiments on hull friction resistance reduction has shown that, as an active method, air lubrication of horizontal hull surfaces is one of the most profitable technique in boundary layer modification hence the frictional drag reduction.

Therefore, this study has been focused on boundary layer modification of horizontally aligned surface by utilizing air jet, injected through a single hole to the cross water flow in a circulating water channel. Profiles of liquid phase velocities, local air volume of fractions as well as turbulence intensities were extracted from the measurements of hot film boundary layer probe by utilising Constant Temperature Anemometry (CTA). Techniques to analyze the CTA signal were developed which provide the reduction of the acquired voltage signal to velocity values by using power law calibration coefficients (linearization), the decomposition of the liquid phase velocity magnitudes with fluctuation levels (turbulence intensities) as well as the local air volume of fraction quantities.

The flow underneath the flat plate was observed by utilizing a high speed camera for the interpretation of the velocity and void fraction profiles of the measurement stations located in the modified boundary layer. Injected air separates into V shaped arm just behind the hole. The angle of the V shape is directly proportional with airflow rate. In contrast, the angle is inversely proportional with free stream velocity. The side view evaluation of the air injection shows that air jet is behaving like a flexible elliptical wedge and creates a cavity behind. In order to understand the structure of the flow field behind the air jet, results of boundary layer velocity profiles with void fraction quantities and wall shear stress measurements were analyzed.

# Measurement and impact of surface topology and hydrodynamic drag of fouling control coatings

P. Stenson, B. Kidd & A.A. Finnie
International Paint, UK

## Abstract

Fouling control coatings that offer fuel savings to ship owners by virtue of their enhanced surface roughness and hydrodynamic drag properties are a key target for the marine paint industry. Despite being of fundamental importance to the shipping industry and the marketing of many fouling control products, surface roughness is a parameter that lacks a standardised industry-wide definition and consensus of approach in the marine paint context. This paper reviews the impact of surface roughness on hydrodynamic drag, methodologies for measuring roughness and the need for precision when processing and reporting data. Results reveal a clear trend in surface roughness between representative examples of some of the most common classes of fouling control coatings in current use. This trend is also mirrored in hydrodynamic drag measurements. However, surface roughness is only one of several inter-connected components that contribute to the overall performance of a fouling control coating and an holistic approach is required in order to fully understand the link between a coating's composition, its surface characteristics, its ability to prevent fouling, its hydrodynamic drag, and its impact on vessel fuel consumption.

# Dynamically verifying the calibration of pressure transducers

A. Bouvy
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## Abstract

An important phenomenon in the maritime world is the vibration of a ship's hull, induced by pressure waves radiated by a cavitating propeller. During model tests, pressure transducers measure these fluctuating pressures. These dynamic conditions contrast with the static calibrations of these transducers.

Resonances and damping are transducer properties that limit the useful frequency range. To verify the validity of the transducer's output signal, a test stand is used in which a harmonic signal excites several transducers under test. The test stand comprises a liquid filled calibration chamber and a signal generator controlled exciter that exerts a harmonically fluctuating pressure to the connected pressure sensors. The excitation signals cover both the amplitude and the frequency ranges as are expected to emerge in the envisaged model test.

# Experimental study of the asymmetrical propeller loads occurring in unmanned self-propelled free running surface model tests

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## Abstract

Propulsion system can experience large power absorption fluctuations during tight manoeuvres. In the case of a turning circle manoeuvre for a twin-screw ship, the power required by the two shaft lines can be completely different; in case of non conventional propulsion system, like cross-connect configurations, a compromise must be met in order to design a safe control system without affecting dramatically the vessel's manoeuvring performance. In this work, a series of unmanned free running self-propelled model tests have been carried out in order to investigate the influence of different propulsion system operation settings on the vessel's manoeuvring characteristics.

# Free running model technology for dynamic positioning in an ice model basin

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## Abstract

Within the European research and development project "Dynamic Positioning in Ice Covered Waters" (DYPIC), a comprehensive set of model tests was performed. The main goal of the project was to develop a Dynamic Positioning (DP) system for an ice model test facility that is adjustable to different ship models and ice conditions. A sub-goal of the project was to have the model run completely without wires while it sails solely on its own propulsion system. The implementation of the setup splits up into three main components: Wireless power supply of the vessel, wireless vessel control and wireless data acquisition. The power supply can be done relatively easy by using batteries. While supplying the vessel with power they serve as ballast weights. For the DYPIC trials two lead accumulators where used – each with a nominal voltage of 12 V and a rated capacitance of 200 Ah. For the control and data acquisition no "of-shelf-solution" exists. Thus a comprehensive setup was developed were data is transferred on several different channels. The tracking of the six degrees of freedom (6-DOF) motion of the vessel is done by an optical motion capture system called Qualisys. The propulsion system (the tested vessels were equipped with azimuth thrusters only) control and measurement is done with a wireless local area network (w-lan) solution of a Siemens control system. Hereby set points for thruster revolution per minute (rpm) and azimuth angle are passed on to the thrusters while their actual values are measured as feedback. In parallel thrust was measured inside the model, where also the measurement amplifier was inside the model. Via a separate w-lan this data was transmitted to a global data acquisition system (DAS) that was located on the main carriage of the ice tank. Here also the rpm and azimuth set points and feedback were logged next to several other channels.

# Open water performance characteristics of a pod propulsor - the benchmark test

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## Abstract

The current paper is a summary of the large test campaign, performed within a framework of Hydro-Testing Alliance Network of Excellence, Joint Research Programme 4 (JRP4, which was focused on investigations of podded propulsors. The previous papers (reported during AMT'09 and AMT'11 Conferences) presented the results of the earlier open water propeller tests as well as their background, incl. descriptions of the JRP4 benchmark tests, related ITTC recommendations and so-called “ABB case", which was treated as a reference base for JRP4 benchmark tests. In the current paper, the results of further studies are presented, incl. open water tests of podded propulsors, performed within a range of different parameters at the testing facilities of JRP4 Participants. Moreover, their comparison with referential "ABB Case" and the final conclusions are discussed.

# Numerical predictions of open water performance characteristics of a podded propulsors - extended studies

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## Abstract

Taking into account the previous experience and conclusions of numerical studies, performed within a framework of Hydro-Testing Alliance Network of Excellence, former HTA JRP4 Participants decided to continue the studies as a new POD CoP (Community of Practice). Thus, the studies presented in the current paper have been realised as a continuation of previous investigations, related to computations of propulsor characteristics (incl. propeller and complete pod unit) at model and full scale by means of different CFD tools. The range of parameters taken into account has been extended, according to the conclusions of the preceding studies; moreover, new CFD codes have been included to the scope. The numerical results are compared to the updated results of the benchmark tests, completed during JRP4 works and the level of agreement is discussed on this basis.

# Prediction of the effect of cavitation on propeller ice interaction

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## Abstract

Modern ice capable vessels have benefited enormously from experimental and full-scale hydrodynamic ice research. However despite the broad international research performed on this topic only a small part of the effort has been applied to the modeling of cavitation during propeller ice interaction. Whilst ice tanks model the contact forces with good agreement, the level and influence of cavitation during propeller ice interaction is often only assumed due to the inability to scale atmospheric pressure during these experiments. This paper gives the findings of the tests performed in the Emerson Cavitation Tunnel examining effect of performance of a podded ice class propulsor operating in simulated ice conditions. The experiment was conducted for multiple short duration ice milling events, which are analogous to those seen in full scale by an ice class podded drive.

A re-analysis of the entire experimental dataset was undertaken to extract and develop extreme value distributions. The paper describes the ice interaction experiment and the construction of Gumbel type distributions from the data. The Gumbel distributions were constructed from the peak torque and extrapolated for different return periods up to 25 years. Trend lines were regressed with linear fits to the extreme value distribution allowing comparison of the model test data with existing full-scale data. Existing full-scale trials data of propeller ice interaction was also examined and compared to assess the influence of cavitation on the torque loads of the propulsion system.

# Automatic waterline registration of a ship model in waves

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## Abstract

Investigation of problems concerning the local freeboard of sea-going vessels requires consideration of several effects, such as squat, bow wave dynamics, wave diffraction and radiation and ship induced motions. Due to the complexity of such problems, captive model tests can be considered as a suitable research method, provided that the instantaneous waterline can be determined in a reliable way. The accuracy of the identification of such issues relies on how well the waterline is determined. This is usually carried out with image processing technique, which, if performed manually, mostly results in a tedious work if large series of model tests are involved.

A typical example of such issues is the seakeeping behaviour of so-called estuary vessels, i.e. inland vessels that can be utilised for short sea voyages on well-defined trajectories in favourable wave condition. Besides additional strength requirements, a seakeeping analysis must comply with prescribed values for the freeboard to ensure no occurrence from green water or flooding of the holds. To investigate this problems, a systematic series of captive model tests was carried out with a 1/25 scale model of an estuary container carrier in the towing tank for manoeuvring in shallow water (co-operation Flanders Hydraulics Research – Ghent University) with different combinations of wave amplitudes and periods, ship speeds and heading angles. During these tests, images of the instantaneous waterline were recorded by an experimental test setup consisting of four black light tubes, a fluorescent coating on the ship model and a computer controlled digital camera. The large amount of images has to be processed automatically, representing new challenges and involving additional issues such as the varying ship position in waves, causing variations in pixel colour and brightness. The present paper intends to describe a method for identifying the waterline profile based on image processing analysis incorporating methods such as: correlation analysis and image registration technique.

# The influence of a keel bulb on the hydrodynamic performance of a sailing yacht model

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## Abstract

The significance of towing tank testing in the evaluation of the performance of ships both in calm and rough waters has been recognised by many authors. For instance, on a competitive sailing yacht design the study of the free surface is of great importance. In towing tank measurements on sailing yachts, the keel is acting as lifting surface at yaw angles $3.5^o$ – $7^o$ which affect considerable all resistance parameters as well as the free surface. The yacht keel features a relatively large laminar region and requires special transition devices which must control both lift and drag components.

Modern sailing yacht designs consist of a keel-bulb configuration. Keel-bulb configuration has beneficial results to the overall stability of the yacht. However, the bulb tends to increase the resistance components. In addition, in some cases, the lift increases, which results to a better windward sailing. Especially in leeway angles $3.5^o$ – $7^o$, where the keel significantly affects the hydrodynamic phenomenon, these phenomena are more intense.

A ¼ scaled model of a 50-ft modern sailing yacht has been tested. The experimental results referring to the drag, the side force, the dynamic C.G. rise and the dynamic trim, are presented. Furthermore, the performance of the model in calm water was evaluated, both with and without the bulb attached to the keel for a grid of heeling and leeway angles. The procedure used for the alignment, the calibration procedure as well as issues of great importance will be discussed in detail. Useful conclusions are drawn following the discussion of the experimental results.

# A quasi-steady method for efficiently conducting open water model tests

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## Abstract

Open water tests of propellers, pod units and thruster units are usually performed in a steady manner where the forward velocity and propeller rotation rate are constant during each measurement. It can require a considerable amount of time in the towing tank to complete an open water diagram with this method. Therefore, a faster method is proposed which applies a quasi-steady approach; the forward velocity of the towing carriage is varied while the thrust and torque are measured continuously. With this method, the normal open water diagram (J=0 to $K_T = 0$) can be determined in one single run through the towing tank instead of multiple runs. This quasi-steady open water (QSO) procedure greatly reduces the time required to perform open water model tests. The method has been tested at MARIN. During those tests, it was seen that there are hysteresis effects on the raw data, but those can be negated by taking the average of the accelerating and the decelerating halves of the measurement. Test results of four different types of propulsors are shown: an open propeller, a ducted propeller, a pod unit and a thruster unit. The results show a very good agreement between the results of the standard, steady procedure and of the QSO procedure.

# Propeller tip vortex cavitation observation technique by using partial blade model

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## Abstract

Most propeller erosion damages are caused by cloud cavitation on the blade surface and unstable tip vortex cavitation on the tip. When strong and unstable tip vortex cavitation damages the trailing edge of propeller tip, the damaged area is smaller than the area eroded by cloud cavitation. The occurrence of damage by tip vortex is affected by not only the global geometry of propeller but also the local shape of blade tip. However, model propeller for cavitation observation test cannot represent the local geometry of full scale blade tip. The conventional cavitation observation test is almost impossible to detect the erosion risk depending on local shape of blade tip.

To examine the erosion induce by tip vortex and its behavior, a propeller of container carrier which damaged by cavitation erosion is adopted. The partial blade model is introduced which reconstructs the shape above 0.7 r/R and detail configuration of blade tip and anti-singing edge in 8.7 times large scale of conventional model propeller. The results of cavitation observation test by using this partial blade model are compared to the damage of full scale propeller.

Also, the CFD calculation with StarCCM+ is carried out to simulate and compare with model test results.

| DAY 1 | Tuesday 17th September | |
|---|---|---|
| 8.00 - 9.00 | Registration & coffee | |
| 9.00 - 9.30 | Opening Ceremony | |
| 9.30 - 10:15 | Plenary Lecture | |
| 10:15 -11:00 | Refreshments | |
| | Session A | Session B |
| 11:00 - 12:15 | Noise Measurements - 1 | PIV Applications - 1 |
| 12:15 - 14:00 | Lunch | |
| 14.00 - 15.15 | EU-FP7 Projects AQUO and SONIC | PIV Applications - 2 & Optical Measurements - 1 |
| 15.15 - 15.45 | Refreshments | |
| 15.45 - 17:00 | Noise Measurements - 2 | Optical Measurements - 2 & Experimental Uncertainty |
| 18:30 - 23:00 | Conference dinner | |
| **DAY 2** | **Wednesday 18th September** | |
| 8:00 - 9:00 | Coffee | |
| | Session A | Session B |
| 9:00 - 10:15 | Coating Performance Measurement | Sensors - 1 & Control Technology |
| 10:15 - 11:00 | Refreshments | |
| 11:00 - 12:15 | Frictional Drag reduction Technology | Sensors - 2 & Smart Free Running Tests |
| 12:15 - 14:00 | Lunch | |
| 14:00 - 15:15 | Pod Propulsor Measurements | Misc. Smart Tank Testing |
| 15:15 - 15:45 | Refreshments | |
| 15:45 - 16:10 | Cavitation Erosion | |
| 16:10 - 16:30 | Closing Ceremony | |