The Royal Institution of Naval Architects

High Performance Sailing Yachts

International Conference on High Performance Sailing Yachts

28-29 October 2015, Southampton, UK

www.rina.org.uk/highperformancesailingyachts

For further information visit:
Call Jade on +44 (0) 20 7235 4622 or email conference@rina.org.uk

DAY 1 PAPERS:

09.00-09.30 **COFFEE & REGISTRATION**

09.35-10.10 **YACHT SAIL FLOW: RECENT FINDINGS AND UNANSWERED QUESTIONS**

Ignazio Maria Viola, University of Edinburgh, UK

This paper aims to review the current knowledge in yacht sail aerodynamics and, in particular, on the characteristic flow features of foresails. Yacht sails are flexible low-aspect-ratio 3D thin wings, which experience a complex 3D turbulent wind and which are capable of developing remarkably high aerodynamic forces. Sail aerodynamics includes a wide range of flow features, spanning from the leading-edge vortex typical of, for instance, insect flyers, to the laminar separation bubble typical, for instance, of low-speed turbo compressors. Our knowledge on the flow field around sails derived from numerical simulations, while quantitative flow measurements have never been performed. Surface pressure distributions were measured with both model-scale sails in wind tunnels and with full-scale sails on the water. These experiments allowed a good understanding of the pressure distributions on sails but limited insights on the correlated local flow field. On the other hand, numerical modelling of sails requires large computational resources because of the complex flow field with separation on curved surfaces and because of the high sensitivity of the flow field to the local angle of attack at the sharp leading edge. Therefore high-fidelity numerical simulations, such as for instance wall-resolved Large Eddy Simulations, have never been attempted before. Less computationally intense hybrid methods (Detached Eddy Simulations) have showed that a leading-edge vortex contributes significantly to the lift of asymmetric spinnakers and that trailing-edge separation occurs at about half of the sail's chord; while a flow field similar to a laminar separation bubble develops from the leading edge of staysails, where trailing edge separation is minimal. However the inability of these numerical methods to resolve accurately the laminar to turbulent transition and the flow at the wall, has led several paramount questions unanswered, such as for instance the effect of the Reynolds number and of the onset turbulence on the performance of sails.

10.10-10.45 **INFLUENCE OF WIND GUSTS ON SAILING YACHT PERFORMANCE**

Milan Kalajdzic, Faculty of Mechanical Engineering, Belgrade, Serbia

The wind is, generally, a time dependent phenomenon, so (due to the changeable wind forces) a sailing yacht motion cannot be stationary. In spite of that, in a great majority of papers, the sailing yacht performance (her speed, list etc) is considered constant, and the influences of wind gusts are neglected. The present investigation exploits the novel techniques developed in the analysis of gusting wind influence on ship stability and safety, and includes the wind gusts and the consequent non-stationary sailing yacht motion into the analysis. The basic procedure is, briefly, the following. The changeable wind speed is assessed from appropriate semi-empirical wind spectrums, and the time-dependent wind forces and moments are included into nonlinear differential equations of yacht's motion. The differential equations are solved numerically, giving the time-history of vessel surge, sway, roll and yaw. From the obtained data, the mean vessel speed, her mean list, etc. are derived by a detailed stochastic analysis. The paper explains, in detail, the tools and procedures used, and give a thorough analysis of several typical examples. It shows how the oscillating yacht motion in gusting wind depends on her type, dimensions and other characteristics. Among other, it focuses on optimal position of the sails, and tries to assess the possible gains in mean speed, if the skipper is able to adjust the sails properly during the non-stationary yacht motion.

10.45-11.15 **COFFEE**

11.15-11.50 **A WING SAIL FOR MAINSTREAM APPLICATIONS**

Greg Johnston, Advanced Wing Systems Pty Ltd, UK

The America's Cup has created a lot of interest in wing sails. Wing sails have been proven to give significant performance gains. However, rigid wing sails are really not usable on most yachts. The infrastructure required to rig, unrig and store wings for other than off the beach craft or those with very deep pockets, is simply not practical. The Semi Rigid Wing (SRW) system is a double surface wing sail that can offer great performance and still keep costs to reasonable levels. The simplicity of design means that sail handling an operation are straight forward. The system hoists, reefs, and stows like a normal sail. The mast forms the leading edge of the sail and parasitic drag from the mast is almost entirely eliminated. The unique, counter rotating design induces section shape and increases the rigidity of the wing, while the mast is typically larger in section than a conventional rig. This means the SRW is a stiffer, lighter, and lower drag rig. This system is now well developed and has undergone significant testing for durability and performance on several types of boats, including more recently a Classe Mini 6.50. The results have been impressive and the learnings have been translated into the design of the world's first one design monohull sports boat incorporating a semi rigid wing sail. This design will be used as a case study to demonstrate the practical application of wing sail technology to every day sailing.

11.50-12.25 **A NEW PHOTOGRAMMETRIC METHOD TO MEASURE FULL-SCALE FLYING SHAPES OF OFFWIND SAILS**

J. Deparday, F. Hauville, P. Bot, Naval Academy Research Institute, France, M. Rabaud, FAST, Paris-Sud, France

Design of sails has been considerably improved those last decades due to more robust and lighter fabrication combined with more detailed research in sail aerodynamics. Downwind sails are complex to study due to highly cambered sections and detached flow around thin flexible sail cloth. Numerical simulations need validation from full-scale experiments which also would permit to better assess this strong fluid-structure interaction system. At full-scale, measuring the flying shapes of spinnakers is valuable for sail designers as they would benefit a feedback to compare them with their design shapes. But it is complex to measure due to their inherent instability, like the flapping of the lu.

On a J/80 class yacht, we simultaneously measured the flying shape of the spinnaker, aerodynamic loads, boat and wind data. We operated a photogrammetric process to record the flying shape of the spinnaker. Aerodynamic loads were measured on the standing rigging as well as on the corners of the spinnaker. In this paper we describe the setup of our experimental measurements, show and analyse four flying shapes from dierent apparent wind angles and compare them with the design shape. The photogrammetric measurement produces flying shapes with an error of less than 4%. This new system will enable measurement of flying shapes moving in time and thus the flapping of spinnakers, valuable for optimisation of performance of sailing yachts.

12.25-13.25 **LUNCH**

13.25-14.00 **COMPARISON OF FSI SIMULATIONS AND FULL SCALE MEASUREMENTS OF YACHT SAILS FLYING SHAPE AND LOADS**

N. Aubin, B. Augier, P. Bot, and F. Hauville, Naval academy research Institut - IRENAV, France

This work presents a full scale experimental study on the Fluid Structure Interaction (FSI) of a yacht rig and sails in real navigation conditions and the recent development on the FSI model ARAVANTI applied to yacht sails. The inboard and dedicated system developed on a J80 yacht have been upgraded to simultaneoulsy and dynamically measure loads in the rigs and sails, sailing data (wind, boat attitude and speed...) and flying shape of the sails. Flying shape parameters are extracted using Vspars system and reconstructed in 3D to be compared with the ARAVANTI simulation. The mean flying shape value is compared to the dynamic shape of steady and unsteady cases. Numerical and experimental comparison gives very good results on both the flying shape and the loads in the rig for upwind condition. Then a simulation case illustrates the limitation of the inviscid fluid approach used inthe study. An upgrade of the model, with a degree of freedom on the heel, is tested and shows a significant improvement in the simulation results, where the attached flow hypothesis overestimates the load. The influence of different trimmings on the main sail and jib on the performance of the yacht are eventually presented.

14.00-14.35 **A WING SAIL FOR MAINSTREAM APPLICATIONS**

Greg Johnston, Advanced Wing Systems Pty Ltd, UK

The America's Cup has created a lot of interest in wing sails. Wing sails have been proven to give significant performance gains. However, rigid wing sails are really not usable on most yachts. The infrastructure required to rig, unrig and store wings for other than off the beach craft or those with very deep pockets, is simply not practical. The Semi Rigid Wing (SRW) system is a double surface wing sail that can offer great performance and still keep costs to reasonable levels. The simplicity of design means that sail handling an operation are straight forward. The system hoists, reefs, and stows like a normal sail. The mast forms the leading edge of the sail and parasitic drag from the mast is almost entirely eliminated. The unique, counter rotating design induces section shape and increases the rigidity of the wing, while the mast is typically larger in section than a conventional rig. This means the SRW is a stiffer, lighter, and lower drag rig. This system is now well developed and has undergone significant testing for durability and performance on several types of boats, including more recently a Classe Mini 6.50. The results have been impressive and the learnings have been translated into the design of the world's first one design monohull sports boat incorporating a semi rigid wing sail. This design will be used as a case study to demonstrate the practical application of wing sail technology to every day sailing.

14.35-15.05 **COFFEE**

15.05-15.40 **SPEEDOMETER FAULT DETECTION AND GNSS FUSION USING KALMAN FILTERS**

Hugo Kerhascoët, Pascal Merien, nke Marine Electronics, France, Johann Laurent, Eric Senn, Lab-STICC, Université de Bretagne SUD, France, Frédéric Hauville, IRENav, Ecole Navale, France

Navigation systems used in racing boats require sensors more and more sophisticated in order to obtain accurate informations in real time. To meet the need for accuracy in the surface speed measurement, the mechanical sensor paddle wheel has been replaced by the ultrasonic sensor. This ultrasonic sensor measures the water speed precisely and with very good linearity. Moreover, by its principle of operation, it measures the water flow several centimeters from the sensor, which allows to be outside the boundary layer, region close to the hull where the flow is disturbed. However, this sensor has several drawbacks: it is quite sensitive and if the flow contains too many air bubbles, the sensor picks up, which can happen quite frequently on boat with planing hull. Another limitation of this sensor is its low frequency measurement rate. In this paper we explain the techniques used based on Kalman filters to address these shortcomings, first by identifying the wrong measurements caused by inadvertent dropouts, then by improving the useful sensor frequency with GPS data fusion.

15.40-16.15 **INCREASING PERFORMANCE WITH SELF-MODIFING AIRFOIL PROFILES**

Roberto Bosi, Inoxsail, Italy

How does it work Essentially, the physical phenomena in the water are equal to those in the air: an airfoil profile develops lift when reached by a moving fluid in determined conditions: the airfoil profile lift is generated by the incidence of the fluid on its surface, that is, the profile is not invested along the longitudinal axis, or the profile itself is asymmetrical. When having a drift and therefore an angle of incidence, PHINNA's profile becomes asymmetrical seamlessly increasing the developed lift and giving that force a better orientation toward boat's advancement direction. The result is the improvement of the angle toward the wind and incremented speed without requiring any action from the crew, nor energy consumption. The automatic adjustment of the profile to the intensity and direction changes of the flow conditions also allows to develop lift at speed and angle ranges that would usually create a stalling effect on the normal symmetrical profiles which are designed for a certain (limited) speed and angle of attack ranges. Therefore, even with little speed or high drift angles, PHINNA is able to develop lift and proves itself hydrodynamically efficient in counteracting the drift and giving the necessary boost for the advancement of the boat. The main feature that distinguishes PHINNA from other similar inventions is being designed with a supporting structure that allows carrying the weight of ballast that counteracts the heeling and, most of all, once installed on the boat, it does not require any intervention from the cockpit. The functioning is entirely mechanical and it is based on the lever principle and Bernoulli's theorem.

16.15- **GENERAL DISCUSSION & DRINKS RECEPTION**

DAY 2 PAPERS:

09.00-09.30 **COFFEE & REGISTRATION**

09.35-10.10 **ON THE DEVELOPMENT OF TOOLS FOR THE DESIGN OF HYDROFOIL CATAMARANS**

Alberto Chapchap, University of Southampton, UK

The development of tools to assist the design of catamaran sailboats with hydrofoils is tackled in the present work under the assumption of static equilibrium. More specifically, the transition from hullbourne to foilbourne mode is modelled by considering a two degree of freedom static problem (heave and pitch) and the performance in the foilbourne mode is analysed by means of six degree of freedom velocity prediction program (VPP). In both of these tools, the hydrodynamic lift and drag coefficients are estimated by a semi-empirical formulation whereas the aerodynamic lift and drag coefficients were obtained from wind tunnel tests. Once the static problem is solved, its solution is then combined in a optimization framework that tries to select a hydrofoil configuration (T or dihedral) and its main dimensions given the objective function. In particular, two gradient free method s are proposed to solve the optimization problem, namely: a genetic algorithm and a coordinate descent algorithm. A structural model is also proposed for the preliminary design of the boat where the forces obtained from the VPP are applied to the boat in a simple 2D structural model. A discussion on the extension of the VPP to the dynamic case and on the incorporation of more complete hydro/aerodynamic models are also presented.

10.10-10.45 **RETRACTABLE PROPULSION SYSTEMS FOR SAILING YACHTS**

Rodd Fogg, Gurit, UK

High performance sailing yachts are continually looking for that performance edge. Increased speed can either be achieved by finding more power, i.e. better rig and sails, or by reducing drag. For racing boats, that only need auxiliary power for short periods, losing the drag of the propeller and shaft has been attractive. As a result, boats such as Volvo 70s have had propulsion systems where the shaft pivots up and down between sailing and motoring modes. Performance enhancements inevitably migrate from racing boats to multi-role racer/cruisers, and particularly those we would call "superyachts" require a more refined solution as comfort is more important. Over the last 25years, composite construction has become the norm for racing boats, and now is dominant for smaller superyachts in the 30-40m range. Composite "P" brackets have been around for many years and the industry is increasingly confident in having composite solutions replace traditionally metal fittings were used. It follows naturally that when looking for performance, some interaction with, or use of, composites is required for Retractable Propulsion Systems. By their very nature, these are novel designs and a mix of machinery and structure design, requiring close collaboration on the 3-D shape and manufacturing method in detail. On modern large composite superyachts, the structure needs to be designed in parallel with the boat systems. This paper reviews developments in Retractable Propulsion Systems and highlights recent systems used on superyachts, and how composite solutions have been achieved.

10.45-11.15 **COFFEE**

11.15-11.50 **DESIGN AND CONSTRICTION OF 60' CRUISING SAILING CATAMARAN**

Albert Nazarov, Ph.D., MRINA, MSNAME, 'Albatross Marine Design Co., Ltd', Thailand

The paper presents case study of design, construction and sea trials of J1800 - 18m cursing sailing catamaran, developed by Albatross Marine Design. The yacht was developed as a 'runaway' custom project for cruising in tropics with access to shallow anchorages, intended for the owner who appreciates sailing performance and comfort. Statistics for sailing catamarans is provided; factors effecting catamaran performance and major trade-offs are featured. Exterior styling and interior planning process is described from initial requirements, first sketches and conceptual stage to final layouts. Design of hull shape is discussed for demihull, wet deck and appendages. Application of low aspect ratio keels versus daggerboards is studied through sailing performance predictions. Structural design of J1800 is performed with application of state-of-the-art 'rulebook' approaches and FEA methods. Given are notes on construction technique using foam cores and E-glass multiaxial/carbon/epoxy laminates. The impact of ISO small craft standards and safety requirements such as multihull size factor, buoyancy, watertight bulkheads, escapes, etc. on resulting design is reviewed. The first J1800 was launched in Thailand in October 2013. Results of sea trials of catamaran are featured, giving a comparison of predicted performance with achieved figures as well as assessment of functionality and comfort. Based on results of research and construction experience, design envelope for feasible performance cruising catamarans is proposed with perspectives for new projects.

11.50-12.25 **THE ATTACHMENT OF BALLAST KEELS ON COMPOSITE SAILING YACHTS: KEEP YOUR KEEL ON!**

David Lyons, The University of NSW, Australia

The role and importance of inter-laminar stress—tensile, compressive and shear—due to out-of-plane loading, in the strength of highly concentrated keel attachments on composite sailing yacht structures is explored. Catastrophic failure in this key area of structure has led to more than a dozen fatalities in the past decade alone. The current state of marine design codes that address the requirement for intact and reserve (post-damage) strength of curved composite structures subject to through-thickness loading is assessed. Sailing yachts are subject to loadings from collision, grounding and broaching. The yacht's keel attachment must absorb these loads. An outline is provided of the experimental and numerical studies that are being conducted for the area over which the keel is attached. The key concepts underlying the research area are composite laminate design theory, construction and inspection practices and the scope for improvement of these aspects in marine composite design codes. As composite laminates are anisotropic, not only must the structural designer consider the variation of in-plane properties with respect to direction, but also the out-of-plane properties. A composite laminate comprises load-carrying fibres and a resin matrix. Through-thickness (out-of-plane) stresses are mostly matrix-dependent. The strength and modulus of the matrix is much less than the fibres. A composite structure subjected to loads that result in through-thickness stresses must be designed with this in mind. This also implies that allowable through-thickness stresses have been determined.

12.25-13.25 **LUNCH**

13.25-14.00 **AERODYNAMIC AND FUNCTIONAL CONSIDERATIONS FOR DESIGN OF SAILING CATAMARAN SUPERSTRUCTURES**

Albert Nazarov, Ph.D., MRINA, MSNAME, 'Albatross Marine Design', THAILAND, Nikolay Jiltsov, 'NJBoats', UKRAINE

With variety of styles, shapes and proportions of today's sailing cruising catamarans, it is important for the designer to consider aerodynamic and functional aspects of catamaran architecture. Different shapes of catamaran cabins representing major trends in the industry were modeled using CFD methods. The modeling included definition of aerodynamic forces and moments and flow visualization at number of apparent wind angles, for each studied version of superstructure. Effect of aerodynamics of superstructure on performance is analyzed by VPP. Practical considerations are discussed in conjunction with results of aerodynamic modeling, covering comfort, appearance, functionality of catamarans. Recommendations on shaping are proposed; design samples showing variations of shapes are featured.

14.00-14.35 **A NOVEL DISPLACEMENT MONOHULL SHAPE FOR IMPROVED PERFORMANCE AND HYBRID PROPULSION, LOWER COSTS AND HIGHER HABITABILITY OF FUTURE SAILING YACHTS.**

Maurizio De Giacomo, Italian Fast Cruisers s.r.l, Italy

The paper describes the hydrodynamics characteristics of a novel type of displacement hull called Top.Glider, which exceeds the critical speed of the typical displacement monohull. Simulations results of 3-dimensional CFD code are compared with towing tank data and a full scale test model of 14.5 m. The scalability of the new design is analyzed for a range of ship lengths, and compared with reference displacement and planing hulls. The study aims to demonstrate the advantages of the design for a wide speed range. The main focus will be on improved performance due to significant reduction of hydrodynamic resistance. The novel approach is to use the same Hull for Motoryachts and Sailing Yachts. Other important aspects such as the reduction of building cost, lower heeling, high performance under engine-power as well as increase of on-board space will be presented.

15.15- **GENERAL DISCUSSION & CLOSE**

International Conference

High Performance Sailing Yachts

28-29 October 2015, Southampton, UK

To register, simply complete all sections of this form and return it with your payment to:

The Conference Department, RINA
8-9 Northumberland Street
London, WC2N 5DA
TEL: +44 (0)20 7235 4622
FAX: +44 (0)20 7259 5912
E-MAIL: conference@rina.org.uk

TITLE (Dr, Mr, Eur Ing):

NAME (as it should appear on name badge):

POSITION:

COMPANY (as it should appear on name badge):

INVOICE ADDRESS:

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

CONTACT MAILING ADDRESS (if different):

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

PLEASE INDICATE YOUR PREFERRED METHOD OF PAYMENT:

I enclose a cheque for: (made payable to RINA) £

Please send me an invoice for : £

Bank Transfer details enclosed for: £

Please debit my credit card by: £

Card Number: (Visa/Amex/Mastercard)

Expiry Date: **Signature:**

How did you hear about this conference?

REGISTRATION FEE (Inc VAT*)	**By 29/09/15**	**After 29/09/15**
RINA MEMBERS:	£400+VAT=**£480**	£450+VAT=**£540**
NON-MEMBERS:	£450+VAT=**£540**	£500+VAT=**£600**

CONCESSIONS: *(Retired/Students etc.)*	£220+VAT=**£264**
PRINCIPAL AUTHOR	£125+VAT=**£150**
ADDITIONAL AUTHOR	£400+VAT=**£480**

The registration fee includes printed conference papers, lunch, refreshments, reception, a CD of the papers and presentations after the conference, and VAT

CONFERENCE PAPERS
Delegates will receive a copy of the conference CD-ROM which will include the presentations, this will be posted out around 10-12 weeks after the conference.

Aditional copies of the conference papers will also be for sale after the event in both print and CD ROM versions. If you would like to order copies, please fill in the relevant sections.

I am unable to attend the conference, please reserve me _______ set(s) of Conference proceedings

Papers @ **£110** (members) ☐ **£130** (non-members) ☐

CD ROM **£110** (members) ☐ **£130** (non-members) ☐

For a full list of the Institution's Conference papers, CD-ROM's and other technical publications please contact Billy Allen, Bookshop Assistant on +44 (0)20 7235 4622 or via e-mail at: publications@rina.org.uk

PAYMENTS
Payment must be made in pounds sterling by Eurocheque, cheque drawn on a bank with a UK branch address, credit card (VISA/Amex/Mastercard) or bank transfer. Please note RINA requires payment before the conference date.
Account Name: The Royal Institution of Naval Architects;
Account Number: 10042127; **Account Code:** 160016
Bank Address: Royal Bank of Scotland PLC, Belgravia Branch, 24 Grosvenor Place, London, SW1X 7HP, UK.
IBAN No: GB14RBOS16001610042127
SWIFT No: RBOSGB2L

*VAT: Under UK Customs and Excise regulations delegates from all countries are required to pay VAT on any course taking place in the UK. Delegates from outside the UK may be entitled to reclaim this cost.

VENUE
The Venue for the conference is: Mercure Hotel, 34 - 35 High Street, Southampton SO14 2HN

EVENING DRINKS RECEPTION
Following the end of day one (28/10/15), delegates are invited to attend an evening drinks reception at the conference venue.

ACCOMMODATION
Upon registration you will be provided with details of a hotel booking service offering reduced rate accommodation for conference participants.

CONTINUING PROFESSIONAL DEVELOPMENT
RINA Certificates of Attendance will be issued at the event, which contributes towards the Institution's Continuing Professional Development Scheme. For further details regarding the scheme please contact Giuseppe Gigantesco, Director, Professional Affairs on Tel: +44 (0)20 7235 4622 or e-mail: membership@rina.org.uk

STUDENT SPONSORSHIP
A number of sponsored places at this conference are available for Student Members of RINA. For more information, please contact Yuen Yee Pang, Professional Affairs, RINA on Tel: +44 (0)20 7235 4622 or e-mail:ypang@rina.org.uk.

PROMOTIONAL OPPORTUNITIES
Why not use this conference to promote your company's products and services? It provides an excellent opportunity to increase your profile and to network with a highly focused audience. We offer a number of cost effective options, including various conference sponsorship packages, exhibition space and literature distribution. If you are interested in any of these promotional opportunities please contact the Conference Organiser to discuss your individual requirements.

CANCELLATION CHARGES
Cancellations received in writing two weeks before the event takes place will be subject to administration charge of £200+VAT. Cancellations received after this time cannot be accepted and are subject to the full event fee. Delegates may be substituted; however, this must be sent in writing and confirmed with the conference Co-ordinator. It may be necessary for reasons beyond our control to alter the content and timing of the programme. In the unlikely event that RINA cancels the event for any reason, our liability is limited to the return of the registration fee.

DATA PROTECTION
Personal data is gathered in accordance with the Data Protection Act 1998. Your details may be passed to other companies who wish to communicate with you offers related to your business activities. Please tick the box below where appropriate:

☐ Please do not pass my information to any third party.

☐ I wish to receive email notification of future RINA events or publications

If you have any questions regarding this or any other RINA event please contact, Jade Whitelaw, Conference Organiser, on:

Tel: +44 (0)20 7235 4622 Fax: +44 (0)20 7259 5912
E-Mail: jwhitelaw@rina.org.uk www.rina.org.uk/events