MADRID DISEÑO DE YATES
Primer Simposio Internacional sobre Diseño de Yates organizado en España.

La Ceremonia de Apertura del Simposio Madrid Diseño de Yates 2004 se celebró en la tarde del 24 de marzo, a las 18:30 h. en el Salón de Actos de la Escuela Técnica Superior de Ingenieros Navales. Estuvo presidida por el Rector de la Universidad Politécnica de Madrid, D.Saturnino de la Plaza, y el Director de la E.T.S.I.Navales, D.Luis Ramón Núñez, junto con representantes de los organismos organizadores: D.Miguel Company, Presidente de ADIN; D.Fernando Bolín, Vicepresidente de la ISAF en representación de D.Gerardo Pombo, Presidente de la RFEV; y D.Alfredo de la Torre, Subdirector de Inspección Marítima de la Dirección General de la Marina Mercante.

Foto 1: Momento de la Ceremonia de Apertura del MDY´04

El MDY´04 recibió a una importante representación de investigadores de relevancia internacional en el campo del diseño y la producción en el sector náutico. Finalmente fueron 21 trabajos los que se presentaron en Madrid, abarcando temas tan interesantes como el diseño de barcos Copa América y Volvo Open 70 (3 trabajos), Hidrodinámica (6), Modelización (4), Estructuras (2), Motor (3) y Nuevas Ideas (3), procediendo de diferentes países, como Francia (1), Estados Unidos (4), Corea del Sur (2), Japón (1), Italia (1), Brasil (1), Portugal (2), Gran Bretaña (2), Holanda (2) y España (5).

Foto 2: Modelo de ensayo de barco IACC situado en la E.T.S.I.Navales

En cuanto a los asistentes, se alcanzó un relevante número de inscritos, llegando a las 163 personas incluyendo a ponentes y organizadores, lo que constituye un completo éxito en convocatorias de este tipo de eventos.

La calidad de los trabajos y la expectación despertada permiten confirmar el éxito de esta primera edición del MDY y su inclusión en el selecto circuito mundial de Simposia sobre Diseño de Yates. Con su celebración en el primer trimestre de los años pares, el MDY se intercala de forma natural entre otros eventos de reconocido prestigio, como son el Chesapeake Sailing Yacht Simposium en Maryland (EEUU) (primer trimestre de años impares), el Yacht Vision en Auckland (NZ) (finales de año impar) y el HISWA en Holanda (finales de año par).

Foto 3: Modelo de ensayo de barco IMS situado en la E.T.S.I.Navales

El MDY´04 cuenta con la Presidencia de Honor de S.A.R. el Príncipe de Asturias, Don Felipe de Borbón y Grecia; está organizado por la Asociación de Industrias, Comercio y Servicios Náuticos; la Asociación de Ingenieros Navales y Oceánicos de España; el Canal de Experiencias Hidrodinámicas de El Pardo; la Escuela Técnica Superior de Ingenieros Navales de la Universidad Politécnica de Madrid; la Subdirección General de Inspección Marítima, Dirección General de la Marina Mercante, Ministerio de Fomento; y la Real Federación Española de Vela. Son Patrocinadores del evento INNOVAMAR, Fundación Instituto Tecnológico para el Desarrollo de las Industrias Marítimas, y PYMAR, Pequeños y Medianos Astilleros S.R., S.A.

El desarrollo de las sesiones

Previo al inicio de la Ceremonia de Apertura, D. Diego Colón ofreció una Conferencia titulada “Restauración de Barcos Antiguos: Proyecto Hispania”, sobre los trabajos de restauración que se están llevando a cabao en el legendario Hispania.

A estos actos asistieron 93 personas, la mayoría asistentes al Simposio que formalizaron su inscripción y recogieron la completa documentación preparada para el mismo. Al finalizar los actos se ofreció un cóctel de bienvenida.

El primer módulo de sesiones del Simposio de Diseño de Yates daba comienzo el jueves 25 según el horario establecido, con una serie de ponencias dedicadas a temas muy actuales en estos momentos en nuestro país: Copa América y Volvo Ocean Race.

Giovanni Ceccarelli ofreció un repaso conceptual al proceso de diseño de un barco de Copa América y sus similitudes y diferencias con respecto al proyecto de un barco de recreo. A continuación, James Dadd explicó el trabajo realizado en el desarrollo de la nueva regla VOR70, el enfoque, parámetros manejados y consultas realizadas, acabando con una comparativa entre los barcos esperados y los anteriores VOR60. En la última sesión del

módulo, Robert Ranzenbach, miembro del Comité Técnico del MDY´04, mostró las investigaciones llevadas a cabo en la modelización de velas portantes para barcos VOR70, de acuerdo con la nueva regla y sus limitaciones en velas.

Después de una pausa para el café, el segundo módulo lo iniciaba Peter Van Oosanen con una interesantísima ponencia sobre el diseño hidrodinámico en barcos Copa América, comparando la regla anterior con la actual, anticipando las características generales de los diseños por venir y señalando los puntos donde es posible una mejora diferencial. Lex Keuning, también miembro del Comité Técnico del MDY´04, continuó con los estudios que desarrolla para predecir la pérdida de velocidad de un barco en el momento de la virada. Acabó el módulo, el portugués Bettencourt, con un trabajo sobre optimización hidrodinámica de las formas de quilla.

Foto 4: La asistencia a las sesiones fue muy numerosa en todo momento

En las sesiones de la tarde, después de la comida ofrecida por la organización, Alberto Fernández del CIMNE de Barcelona, ofreció un innovador sistema de predicción de prestaciones de los barcos de regata teniendo en cuenta predicciones estocásticas de la meteorología. Fernando Quero, de la Univ. de La Almunia, expuso el exitoso sistema de navegación desarrollado por dicha Universidad y que se aplica en barcos IMS y Copa América. Cerró el módulo Richard Korpus, con un trabajo sobre la aplicación de CFD en el proceso de diseño hidrodinámico de los barcos.

Para finalizar, después del café de la tarde, Francisco Machado de Portugal, presentó el proyecto de análisis estructural de una barco de crucero/regata de 30´ utilizando elementos finitos. Y para acabar, Giovanni Belgrano, de SP Systems, expuso con claridad y sencillez las dificultades que se encuentran en el proceso de diseño estructural de una barco y cómo se resuelven, mostrado ejemplos de los últimos y espectaculares proyectos desarrollados, como el del Mari Cha IV.

El viernes 26, segundo día de sesiones del Simposio de Diseño de Yates, comenzaba con el módulo dedicado a las embarcaciones de motor. Alan Gilbert, del SNAME y con gran experiencia en proyectos de yates a motor, presentó una reveladora y básica metodología para estimar la distribución de pesos de un yate y realizar una predicción de velocidad con gran exactitud. A continuación, dos interesantes trabajos desde Corea del Sur, el primero presentado por un grupo liderado por Jeongil Shin sobre los estudios de canal en yates de motor de alta velocidad, y el segundo por otro grupo liderado por Seung-Hee Lee sobre el desarrollo de catamaranes de pequeño tamaño dedicados a pesca y recreo.

En el siguiente módulo se agrupaban trabajos de temas diversos bajo el epígrafe “Nuevos conceptos”. Desde Brasil, Ronaldo Fazanelli presentó un interesante trabajo sobre el desarrollo de un proyecto de construcción de un barco de la clase Mini 6.50, que se apoya en los estudios realizados sobre los barcos participantes en la última edición de la Mini Transat,

con final en Salvador de Bahía. El siguiente trabajo programado, desde Japón, no pudo presentarse en las sesiones por la repentina enfermedad y consiguiente ausencia de su autor, Takeshi Kinosita, aunque el estudio sobre catamarán con hidrofoils para un solo tripulante figura en el libro de ponencias del Simposio. Cerró el módulo una interesante presentación sobre el proyecto para batir el record de velocidad a vela que lidera Fulgencio García, con el apoyo de Izar, y para el que se han llevado a cabo innovadores estudios en el Canal de El Pardo sobre hidrofoils.

Después de la comida, Philippe Pallu de la Barriere, del CRAIN francés, el instituto de investigación aplicada a la náutica, presentó los trabajos desarrollados sobre CFD y la aplicación de soluciones RANS al tratamiento de los fluidos, que se plasma en el código ICARE que ya se utilizó en el desafío francés a la Copa América 2003, AREVA. A continuación, dos trabajos de instituciones españolas que muestran las excelentes posibilidades que existen en nuestro país para el desarrollo de I+D en la náutica. Carlos López, del Canal de Ensayos de la E.T.S.I.Navales, presentó un trabajo preparado por un grupo de investigadores de la Escuela sobre la configuración de apéndices en barcos de la clase VOR70. Las diferentes combinaciones de quilla basculante con orzas de deriva asimétricas o dos timones en crujía han sido evaluadas, en lo que supone una primera aproximación a este tipo de diseños que estarán de actualidad en los próximos meses. Desde el CEHIPAR, Jesús Valle presentó en nombre de un equipo de investigadores del Canal de Ensayos de El Pardo el primer estudio meteorológico comparativo que se hace del campo de regatas de la próxima Copa América, Valencia, con respecto al existente de la pasada edición en el Golfo de Hauraki.

Para concluir con la presentación de trabajos, Robert Ranzenbach resaltó la evolución que se está produciendo en el diseño de velas con la aplicación de códigos CFD y análisis estructurales basados en Elementos Finitos de forma conjunta, lo que permite anticipar de forma mucho más ajustada el comportamiento de la vela en condiciones reales y con ello aquilatar al máximo la disposición del material y de los paños. Con estos nuevos sistemas, el velero entra en el proceso de diseño de un barco desde el inicio con importantes mejoras en el resultado final por la interacción con otros apartados del diseño (casco, aparejo).

Y para finalizar el Simposio, Ricardo Zamora, Subdirector de Investigación de la E.T.S.I.Navales y miembro del Comité Técnico del MDY´04, cerró el acto con unas palabras de agradecimiento a los ponentes, asistentes, patrocinadores y entidades organizadoras e invitando a todos los presentes a la siguiente edición de Madrid Diseño de Yates, MDY´06, que ya se comienza a preparar.

Para más información, http://www.etsin.upm.es/Noticias/mdy04/index.html.

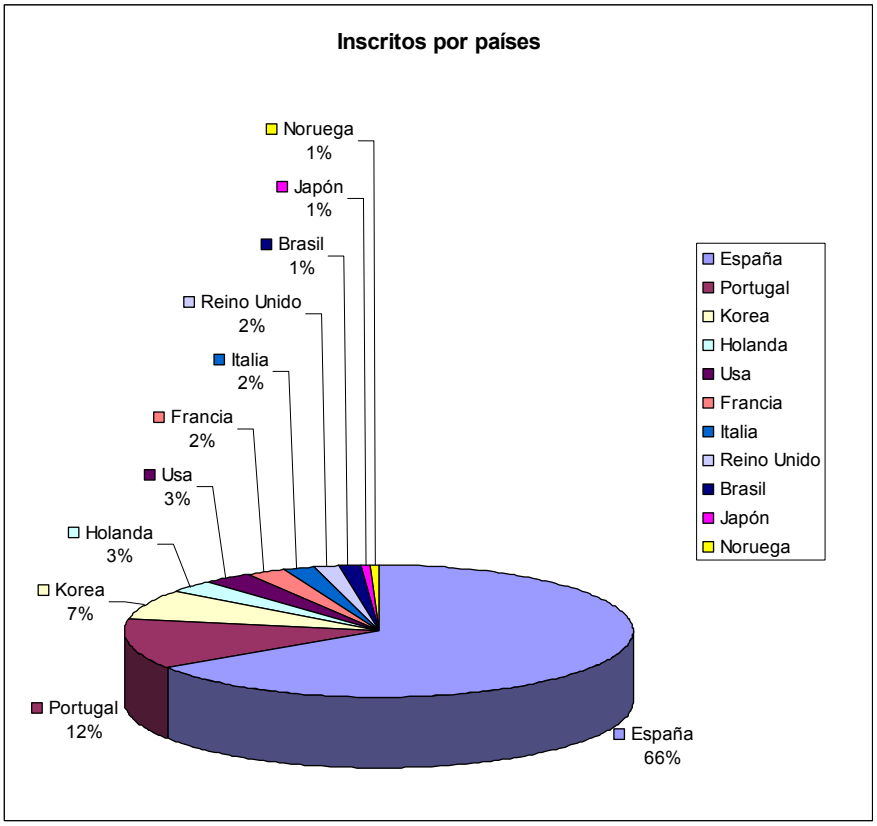
Informe sobre inscritos y asistencia a las ponencias.

Introducción

Este informe está realizado con los datos obtenidos de las fichas de inscripción en el Simposio. El total de inscritos es de 163, incluyendo a los ponentes y a la organización.

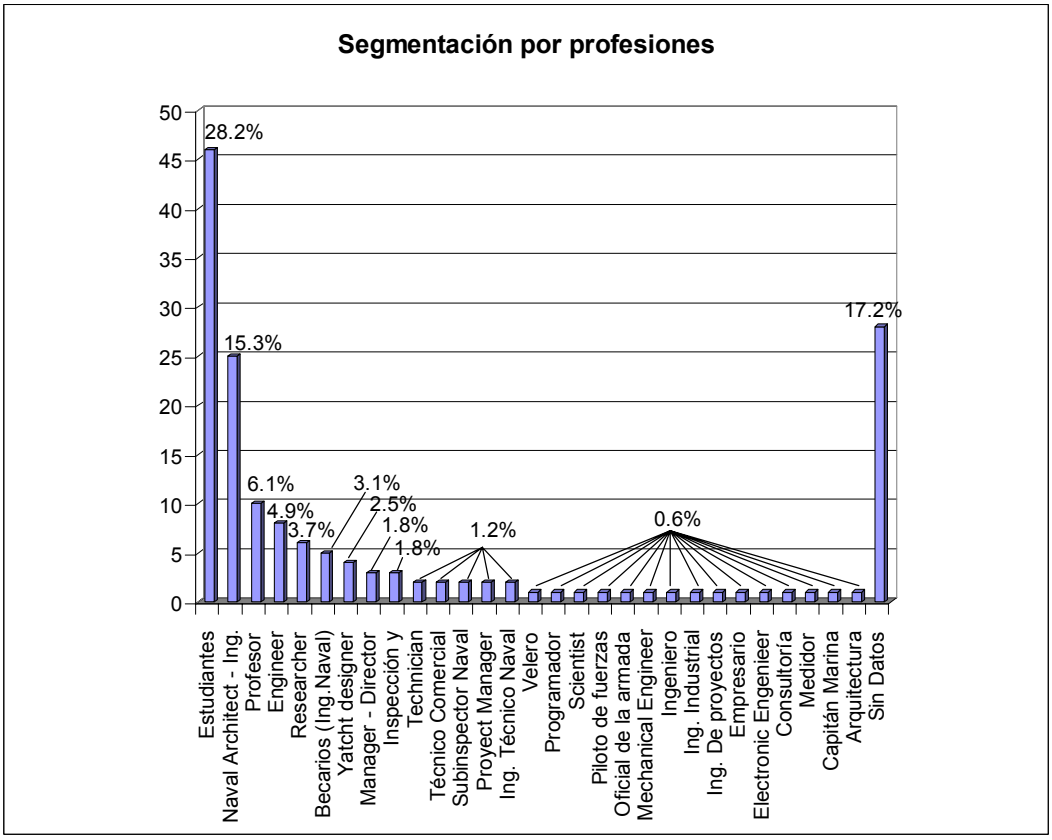
Segmentación por nacionalidades.

País	Nº	%
España	107	66
Portugal	20	12
Korea	12	7
Holanda	5	3
Usa	5	3
Francia	4	2
Italia	3	2
Reino Unido	3	2
Brasil	2	1
Japón	1	1
Noruega	1	1
	163	100



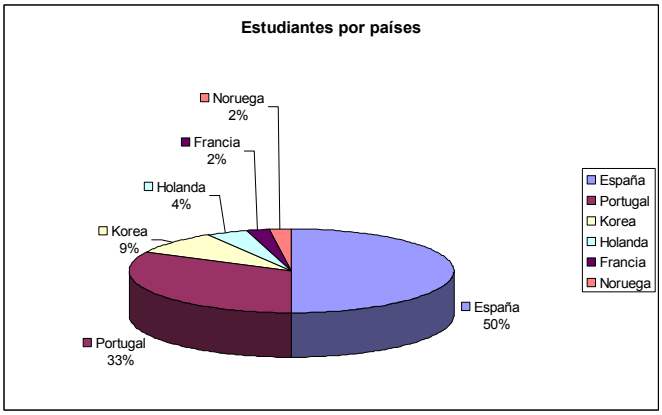
Segmentación por profesiones.

Profesión	Nº	%
Estudiantes	46	28.2
Naval Architect - Ing. Naval	25	15.3
Profesor	10	6.1
Engineer	8	4.9
Researcher	6	3.7
Becarios (Ing.Naval)	5	3.1
Manager - Director	3	2.5
Inspección y certificación	3	1.8
Technician	2	1.8
Técnico Comercial	2	1.2
Subinspector Naval	2	1.2
Project Manager	2	1.2
Ing. Técnico Naval	2	1.2
Velero	1	1.2
Programador	1	0.6
Scientist	1	0.6
Piloto de fuerzas aereas	1	0.6
Oficial de la armada	1	0.6
Mechanical Engineer	1	0.6
Ingeniero Telecomunicaciones	1	0.6
Ing. Industrial	1	0.6
Ing. De proyectos marinos	1	0.6
Empresario	1	0.6
Electronic Engenieer	1	0.6
Consultoría	1	0.6
Medidor	1	0.6
Capitán Marina Mercante	1	0.6
Arquitectura	1	0.6
Sin Datos	28	17.2
	163	100.0

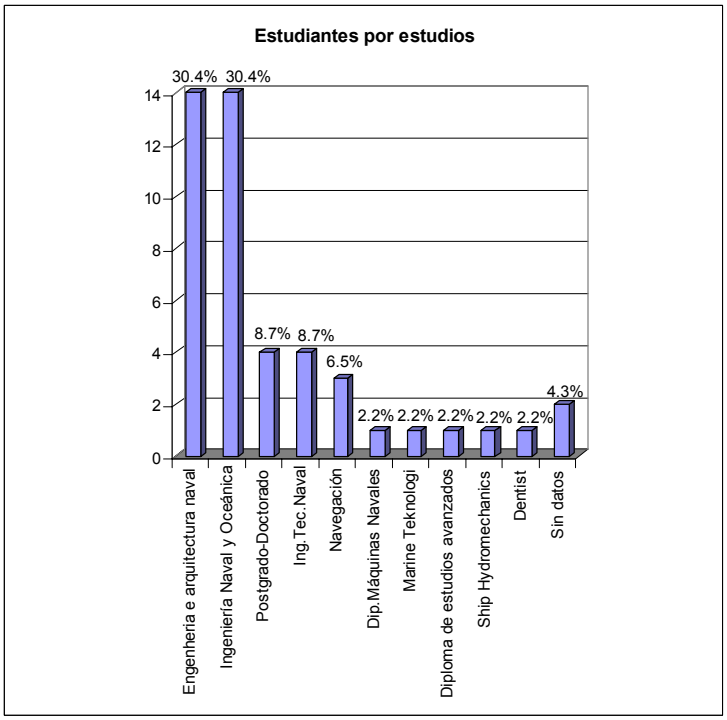


Segmentación de los estudiantes por países y por carreras:

País	Nº	%
España	23	50
Portugal	15	33
Korea	4	9
Holanda	2	4
Francia	1	2
Noruega	1	2
	46	100



Estudios	Nº	%
Engenheria e Arquitectura Naval	14	30.4
Ingeniería Naval y Oceánica	14	30.4
Postgrado-Doctorado	4	8.7
Ing.Tec.Naval	4	8.7
Navegación	3	6.5
Sin datos	2	2.2
Dip.Máquinas Navales	1	2.2
Marine Teknologi	1	2.2
Diploma de estudios avanzados	1	2.2
Ship Hydromechanics	1	2.2
Dentist	1	4.3
	46	100.0



Segmentación por tarifa y precio.

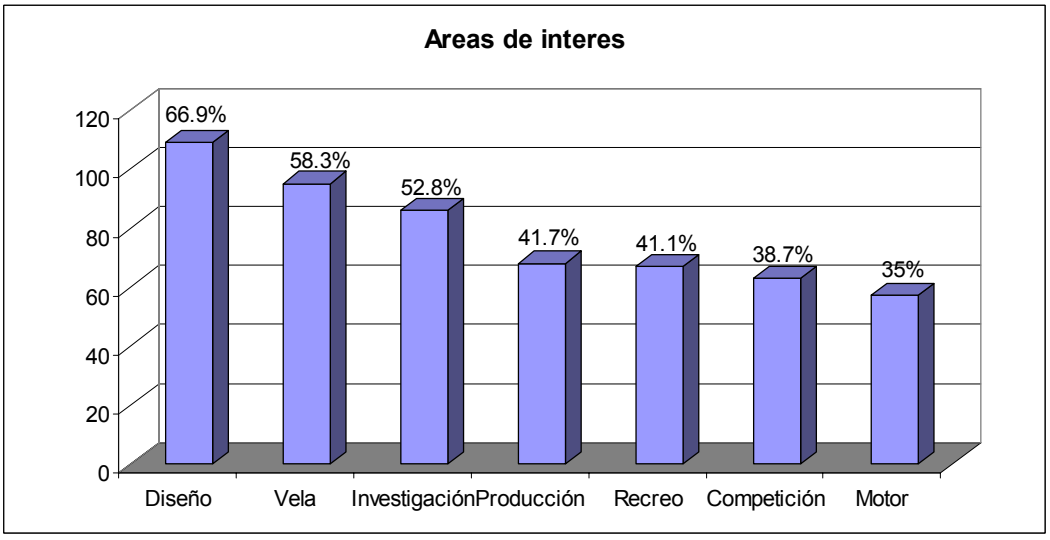
En esta tabla aparece la cantidad de 270 en el apartado de ponentes. Este es el dinero que pagaron los Coreanos por sus inscripciones y las de sus acompañantes. El resto de ponentes no pagaron nada. Alguno de estos ingresos está pendiente de confirmación por parte del colegio (confirmación de haber recibido la transferencia).

Tarifa	Pagado (€)	Nº	Ingresos (€)	Total (€)
Federación	30	10	300	480
	60	3	180	
Ponentes	270	41	270	270
Organización		11		
Estudiantes	30	44	1320	1560
	60	4	240	
AINE	30	18	540	780
	60	4	240	
General	60	17	1020	1740
	120	6	720	
CEHIPAR	30	5	150	150
		163	4980	4980

Resumen de las áreas de interés:

Datos sobre un total de 163 inscritos.

Area	Interesados	%
Diseño	109	66.9
Vela	95	58.3
Investigación	86	52.8
Producción	68	41.7
Recreo	67	41.1
Competición	63	38.7
Motor	57	35.0



Información de la asistencia a las conferencias.

Estos datos están recogidos directamente del aforo de la sala de conferencias en cada ponencia. Téngase en cuenta que de los 163 inscritos no todos acudieron al simposio.

			Wednesday 24/03/2004	Persons
17:30	to	17:50	**Diego Colón**: · *Restauración de Barcos Antiguos: Proyecto Hispania*	**90**
18:30	to	19:00	**OPENING CEREMONY**	**81**

			Thursday 25/03/2004	Persons
09:00	to	09:35	**Giovani Ceccarelli**: · *On the approach to designing an IAAC yacht :- experience, methodology and observations - correlation with the world of yachts and pleasure craft*	**98**
09:35	to	10:10	**James Dadd**: · *Class rule development – the volvo open 70*	**109**
10:10	to	10:45	**Teeters & Ranzenbach:** *Volvo 70 Offwind Aerodynamic Modeling and Its Impact upon Sail Inventory & Design Optimization*	**105**
11:15	to	11:50	**Peter van Oossanen:** *Recent Developments in the Design of America's Cup Yachts*	**126**
11:50	to	12:25	**J.A.Keuning and K.J.Vermeulen:** *Approximation method for the loss of speed during the tacking maneuver of a sailing yacht*	**125**
12:25	to	13:00	**Bettencourt, Fonseca, Guedes Soares**: · *A procedure for the optimization of the hydrodynamic performance of sailing yachts keels*	**117**
14:30	to	15:05	**Fernando Quero Sanz**: *Racing Bravo*	**119**
15:05	to	15:40	**Alberto Fernandez**: *Stochastic evaluation of Sailing yachts performance in regatta fields*	**111**
15:40	to	16:15	**Richard Korpus:** *Reynolds-Averaged Navier-Stokes in an Integrated Design Environment.*	**107**
16:45	to	17:20	**Machado Santos, Duarte, Guedes Soares**: *Finite Element Analysis of a 30ft one-off Racer-Cruiser Yacht*	**98**
17:20	to	17:55	**Giovanni Belgrano**: *Structural Design of High performance race yachts*	**104**

			Friday 26/03/2004	Persons
09:00	to	09:35	**Alan A. Gilbert**: *Taking the mistery out of speed predictions*	**70**
09:35	to	10:10	**Jeongil Shin**: *Evaluation of Resistance Performance of a High-speed Motor Boat Using unmanned High-Speed Towing Carriage*	**68**
10:10	to	10:45	**Seung-Hee Lee**: *On the Development of a small Multi- hull pleasure fishing boats*	**76**
11:15	to	11:50	**Ronaldo Fazanelli Migueis**: *Development and building of a Mini 6.5 for the Mini-Transat 2005*	**88**
11:50	to	12:25	**Fulgencio García**: "Volador" An hidrofoil for the world sailing speed record	**90**
12:25	to	13:00	**Takeshi Kinoshita, Yasuhiro Sudo, Kiyoshi Uzawa and Koutarou Horiuchi**: *Overview and current state of a new single-handed hydrofoil sailing catamaran*	**-----**
14:30	to	15:05	**Pallu de la Barrière & Védrenne**: *Application of Rans Calculations to the design of Sailboat Hulls*	**92**
15:05	to	15:40	**Carlos López:** *Hydrodynamic study of a canting keel based appendages configuration.*	**96**
15:40	to	16:15	**Eloy Carrillo**: *America's Cup seakeeping: meteorological analysis Valencia vs Hauraki*	**104**
16:45	to	17:20	**Ranzenbach & Xu**: *Fluid-Structure Interaction Simulation of Reaching Sails*	**91**
17:20	to	17:55	**CLOSING**	**91**

Average (only conferences)	**100**
Average (first day)	**111**
Average (second day)	**86**

Listado de Trabajos presentados

On the approach to designing an IAAC yacht :
- experience, methodology and observations -
- correlation with the world of yachts and pleasure craft -

Giovanni Ceccarelli [1]

Abstract

In this paper I would like to explain how the work of the design team that I led in the last America's Cup campaign was structured and then make some observations on the organisation of a project team for a hypothetical future challenge.

The last America's Cup campaign saw the overt introduction of CFD and FEM, two tools that will be adopted ever more widely in the future.

I believe that the management of an America's Cup project can provide analogies with the implementation of projects in the field of mass-production.

My final observation concerns the concept of design in the project sense and this can serve to summarise a number of ideas on the organization of an America's Cup team.

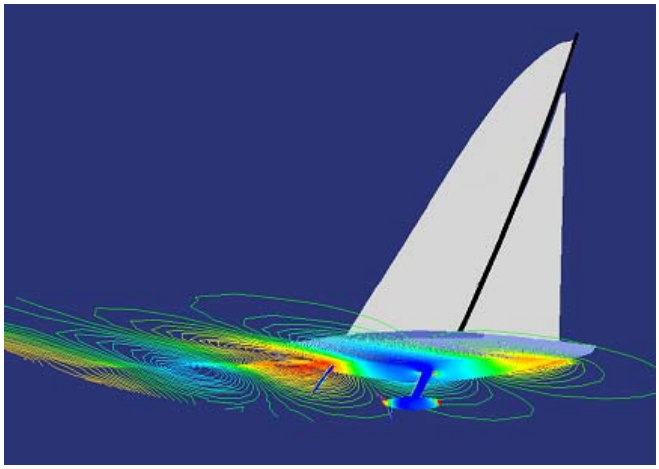


Fig. 1 Example of computed pressure distribution for a generic IACC

Class rule development – The Volvo Open 70

James Dadd [*]

Introduction

The RORC Rating Office has been connected with the Volvo Ocean Race and it's predecessor (The Whitbread Round the World Race) issuing IOR Rating certificates since the first race, and as the administers of the Whitbread/Volvo Ocean 60 since it's inception in the 1992-93 edition of the race. Following on from the experience of the late John Warren's management of this class, Volvo Event Management approached the RORC Rating Office to develop a new rule for a new breed of yachts for the event. By then John had just retired, although he stayed on as a consultant through the rules development.
As Chief Measurer for the Rating Office and being the current chief measurer for the Volvo Ocean 60 rule, a class measurer for the Farr 40s, Mumm 30s, European measurer for the America's Cup Class, the intriguing task landed on my desk.

Volvo 70 offwind aerodynamic modeling and its impact upon sail inventory & design optimization

Dr. Robert Ranzenbach [*],Jim Teeters[**],

Introduction

Improved offwind aerodynamic models are particularly important when undertaking design projects for yachts competing in offshore distance races commonly dominated by offwind sailing such as the Volvo Ocean Race [Ranzenbach et al, 1999].

A Cooperative effort between Quantum Sail Design Group (QSDG), Glenn L. Martin Wind Tunnel (GLMWT), and Teeters Yacht Technology (TYT) previously developed an enhanced offwind aerodynamic model, which consisted of different nominal performance coefficients and an alternative formulation to the depowering element based upon experimental results [Ranzenbach & Teeters, 2003].

This enhanced offwind aerodynamic model and a more conventional IMS style offwind aerodynamic model are applied here in a Velocity Prediction Program (VPP) simulation for two generic Volvo 70 designs (the two different designs represent different corners of the Volvo 70 design space). The predicted performance and sail inventory charts for the two boats using the enhanced offwind aerodynamic modeling approach is presented and discussed. A comparison to results using a conventional IMS style offwind aerodynamic model is presented and discussed. These discussions highlight the necessity for high fidelity offwind aerodynamic models to properly optimize the design of high performance yachts.

Recent developments in the design of America's cup yachts.

Peter van Oossanen [*]

Abstract

In this paper a review is presented of recent trends in the design of America's Cup Class (ACC) yachts, in particular with respect to the design of the canoe body and the appendages. These trends are presented as a logical result of the continuing search for more speed. For example, it is shown that the search for designs with better all-round performance has resulted in narrower hull forms. Likewise, the quest to find higher speeds sailing upwind, at relatively large angles of heel, has resulted in the adoption of extremely U-shaped sections.

After critically examining the America's Cup Class Rule, including the new version thereof to be used for the next event in 2007, an overview of some notable design trends and innovations during the 1992 to 2003 period is presented. More recent developments in the design of ACC yachts, both those that are apparent to the trained eye and some that are perhaps not so apparent, are then examined. Aspects of the canoe body and the appendages to which a lot of attention is now focused, are discussed.

Many experienced designers are of the opinion that further design innovations, leading to a significant jump in performance, are no longer possible within the constraints of the existing ACC Rule. This topic is also discussed.

Approximation method for the loss of speed during the tacking maneuver of a sailing yacht.

E J de Ridder[1], J A Keuning[2], K J Vermeulen[3]

Abstract

In the present report the first results of a study on the speed loss of a sailing yacht during a tacking maneuver are presented. The study aims at the development of a generally applicable generic mathematical model for the determination of the speed loss of an arbitrary sailing yacht during a tack. The results of such a simulation model for various yachts may be implemented in a VPP to make an assessment of the differences in the speed loss of various designs into account for handicapping purposes. The simulation model should then be made generally applicable to an arbitrary yacht without extensive and complicated calculations.
In an earlier study Keuning and Vermeulen, Reference [1], presented an approximation method for the yaw force and the sway moment of an appended sailing yacht hull under steady forward motion and under the influence of leeway and heel. In the present study these formulations are slightly modified to improve correlation with the types of yacht under consideration and implemented in the mathematical model for the maneuvering of sailing yachts as presented by Y Masayuma, Reference [2]. Also the resistance curve as developed within the DSYHS is taken into the mathematical model. The goal of all this is to develop a relatively easy to use and generally applicable maneuvering model of which the necessary "hydrodynamic coefficients" in the model may be obtained from calculations derived from results obtained with the models of the Delft Systematic Yacht Hull Series (DSYHS). The velocity terms are [1]introduced now the acceleration terms follow later. Validation of the results is presently executed with measurements from Masayuma but will be extended to foreseen full scale measurements within this project in the near future.

A procedure for the optimization of the hydrodynamic performance of sailing yachts keels

J. Bettencourt, N. Fonseca and C. Guedes Soares[*]

Abstract

This paper describes a methodology to find the optimal keel through a formal optimization procedure. The optimization scenario is a yacht sailing to windward with constant hull speed, heel and leeway angles, assuming that the risk of keel stall and loss of hydrodynamic side force is negligible. Since the keel's plan form is the most important feature related to side force generation, the type of the keel sections is kept the same throughout the optimization procedure The hydrodynamic properties of the candidate keels are assessed by a set of methods that tackle each of the sub problems that, altogether, make up the hydrodynamic problem of the fin keel, i.e. finding the side force and resistance components of a keel with a given plan form. Hull presence effects on the keel's side force production are considered through the use of an empirical wing – fuselage interaction factor. Other sources of interference are neglected. A deterministic search algorithm is used to solve the nonlinear programming problem.
The results obtained with the application of this methodology to a specific case show that good improvements are attainable. The computational effort is small if the optimization parameters are carefully selected, particularly the inequality constraints limits and the initial candidate keel.

Stochastic optimization of IACC yacht performance

A. Fernández[1], A. Valls[1,2], J. García-Espinosa[2]

Introduction

In recent years, the use of deterministic race modelling programs (RMP) has become more and more popular among racing yacht skippers to help with their route planning decisions. They are very common now in round the word races and long oceanic regattas. In coastal regattas, however, they are not that common.

In parallel, this kind of methodologies has started to be applied in the design phase of some high end projects such as America's Cup yachts. The first use of these tools in an America's Cup design was reported in 1987 by Stars & Stripes.

However, the planning of routes for sailing vessels is subject to uncertainty from the weather. This is particularly important in yacht racing where the accuracy of a weather prediction can determine the outcome of a race. With a perfect weather forecast it is possible to use the polar tables of a given yacht to compute a route that minimizes its arrival time at its destination.

If we focus on the design phase, the uncertainty of weather becomes a new variable of the problem, making the stochastic analysis of the routing problem a crucial point if we intend to optimize the design.

The traditional approach to the optimization of sailboats was based on the educated analysis of the polar curves of the vessel. Before the dawning of velocity prediction programs (VPP), this approach was even more limited in the sense that it involved the optimization of ship resistance and not of ship speed (i.e. the searching for an optimum form coefficient for a given velocity). The interaction between the ship resistance, the stability and the aerodynamic forces is neglected. A further improvement of this model came with the introduction of the VPP.

The VPP calculates the speed of the boat for each angle of sailing and for each wind speed. Now the designer is capable of considering the trade off between performance with low winds vs performance with high winds, or off-wind vs up-wind. The connection between the performance of the boat and the weather is still made by estimation of a weight function of the speed in different points of sailing; or, even, by a simple visual examination of the shape of the polar curves. The approach proposed in this paper involves a closer connection between the weather and the yacht performance.

The common approach of the RMP for design application usually uses the output from a VPP along with historical weather data to assess different yacht designs, by racing candidate designs over a range of weather scenarios.

This work presents a new approach to the stochastic analysis and numerical simulation for high performance yacht design. We consider the problem of finding the best ship, that which maximizes the probability to win a race under stochastic weather conditions.

It seems logical to treat the weather as a stochastic process. Thus, the conditions in which the boat sails can be expressed as a random variable. This random variable has an occurrence probability associated. Therefore, the best boat under that random sailing condition has a better chance of winning the regatta.

This paper is laid out as follows. First the statement of the problem is presented, in terms of the necessary discretización of the racing area for the numerical simulation of the process. Afterwards, the methodology for yacht performance and race modeling is shown. Then the route optimization algorithm developed to calculate best route to goal and the stochastic methodology used are presented.

Finally, as an example, the analysis of different alternative designs to one real IACC ship is included.

RACING BRAVO. Un sistema de navegación para alta competición

Alfredo Pons, David Asiain, Fernando Quero, Javier Cuevas, José Luis Vela, Juan Carlos Sánchez [*]

Introducción

SISTEMA es el resultado visible del trabajo del Centro I+D EUPLA en los apartados de instrumentación, medición, procesado y análisis de parámetros de navegación en tiempo real para embarcaciones de alta competición. Trabajos que empezaron con la participación en el Desafío Español de Copa América como Patrocinador Oficial Tecnológico y que han sido continuados posteriormente en las embarcaciones BESST en el 2002 y 2003 y Bribón en el 2003 y 2004.

Este proyecto nació de la necesidad técnica de los desafíos Copa América de reconfigurar e insertar nuevos desarrollos e investigaciones en la electrónica de a bordo con el fin de mejorar la precisión de intensidad y dirección de viento , así como poder centralizar y sincronizar los parámetros principales de navegación (velocidad, escora, viento, posición, etc.) con datos técnicos avanzados como esfuerzos en aparejo, sustentación y resistencia de apéndices, datos estructurales de quilla, etc.

La versión actual del SISTEMA es una evolución mejorada del sistema de navegación desarrollado para el Desafío Español de Copa América y pretende establecer una innovación tecnológica tanto en embarcaciones de tipo IACC, como en el ámbito global de la Vela.

Fluid-structure interaction simulation of a code zero sail

Dr. Robert Ranzenbach [1], Dr. Zhenlong Xu [2].

Introduction

In recent years, substantial progress has been achieved in Computational Fluid Dynamics (CFD) simulation of sails and this has made CFD a potentially powerful tool for sail designers. However, CFD's utility in this regard has been limited by the common necessity of knowing the actual flying shape prior to performing aerodynamic calculations rather than being able to rely upon available design shapes which are normally quite a bit different.

In this paper, a method is presented to conduct an integrated Fluid-Structure Interaction (FSI) simulation of sails that is based upon knowledge of the design shape geometry and sail material properties. A Finite Element Analysis (FEA) of the sail structure and a CFD model of the aerodynamic field are combined and iteratively solved to compute the actual flying shape of the sail under aerodynamic load, the stress-strain behavior of the sail membrane, the integrated aerodynamic forces produced by the sail such as driving force and heel moment, and the resulting loads on sheets, halyards, etc. An important contribution of this particular method is the incorporation of wrinkling phenomena into the FEA portion of the calculation.

Finite element analysis of a 30ft one-off racer-cruiser yacht.

F.Machado Santos, J.Mendonça Santos, F.Duarte and C.Guedes Soares [*]

Abstract

The article describes a structural finite element analysis of a sailing yacht made of sandwich core laminates. The hull structure basically consists on laminates made of epoxy resin reinforced with unidirectional and bi-axial fibres bounded to cores of variable densities for different areas of the hull. Transitions from sandwich to monolithic are adopted in hull to deck joints, deck equipment insertions, keel fixation area, rudder stock area and commonly known areas to be susceptible to compression.

A finite element analysis is presented in order to identify critical areas where possibly reinforcement or redesign is to be considered. Results for several primary load cases are shown, which include rig loading, hydrostatic and hydrodynamic loading. At this stage the sandwich panels will be considered as membrane loaded elements, and stress/strain distributions on hull and deck are to be presented. The calculations are made in the linear elastic domain based on a layered structural shell finite element that allow definition of fibre orientation and core material properties.

In addition, empirically estimated forces induced by keel and rudder will be included in the finite element model in order to characterize the secondary structure behaviour in predefined areas.

Working load to break load: Safety factors in composite yacht structures

Giovanni Belgrano[1]

Abstract

The loads imposed on yacht structures fall broadly into two categories: the distributed forces imposed by the action of the wind and waves on the shell of the yacht, and the concentrated loads imposed by the rig and keel to their attachment points on the structure. This paper examines the nature of the latter set of loads and offers a methodology for the structural design based on those loadings.

The loads imposed on a rig attachment point vary continuously while the yacht is sailing. Designers frequently quote "working load", "safe working load", "maximum load" or "break load" for a rigging attachment, but the relationship of this value to the varying load is not always clear. A set of nomenclature is presented to describe clearly the different load states from the "steady-state" value, through the "peak, dynamic" value to the eventual break load of the fitting and of the composite structure.

Having defined the loads, the structure must be designed to carry them with sufficient stiffness, strength and stability. Inherent in structural engineering is the need for safety factors to account for variations in load, material strength, geometry tolerances and other uncertainties. A rational approach to the inclusion of safety factors to account for these effects is presented. This approach allows the partial safety factors to be modified to suit the choice of material, the nature of the load and the structure and the method of analysis.

Where more than one load acts on an area of the structure, combined load cases must be developed that model realistically the worst case scenario. In particular if the loading is quasi-static, the total loads on the structure must be in equilibrium. This is particularly important for Finite Element Analysis since an unbalanced load case can lead to excessive reactions at the points of restraint of the Finite Element Model. A method is presented for the development of a balanced load case for upwind sailing which allows significant insight into the behavior of a yacht structure under "real" sailing conditions. The keystone of this approach is a method for

constraining the model in a statically-determinate manner, to avoid adding unrealistic stiffness to the model.

Finally, once the structure has been built, it is sound practice to proof test it to give confidence in its reliability. The value of load for proof testing is a difficult choice but is made more straightforward by the rational approach to load definition presented in the paper.

Taking the mystery out of speed predictions.

Alan Gilbert. [1]

Introduction

One of the most important design parameters for a yacht is speed, especially a motor yacht. Failing to make speed can be a disappointment to the owner, and it very definitely reflects negatively on our profession. The worst scenario result is an owner so thoroughly disgusted with his yacht that he drops out of yachting, replacing his mega-yacht with a villa in Southern France. Thus denying everyone in the industry potential future work.

As an independent naval architect, in addition to my own projects, I have been often called upon by owners, other naval architects to determine why a yacht did not make speed. These opportunities provide a perspective on how others deal with the question of speed. Too often I find the reason for not making the contract speed is because basic mistakes were made during the design/construction process. While nobody is immune to errors, there are several things, which can be done to minimize the possibility of a mistake.

The laws of motion have not changed since Sir Isaac Newton. It takes so much force to propel a mass (yacht), at a given velocity (knots). While there have been breakthrough hull forms (multi-hulls, SWATH, etc.) nobody is "pulling rabbits out of hats." If the vessel weighs so much, and you want to go so fast, you need a certain amount of horsepower, and no less. Reliable speed predictions can be obtained with careful and thorough engineering. It is just as important to be realistic. If something sounds too good to be true, it probably is.

The major elements that go into reliable speed predictions are:

1. Weight, and Centers
2. Displacement
3. Resistance data
4. Prime mover horsepower (engines)
5. Propulsor (propellers, water jets, etc.)
6. Assimilation of Data

While this list is obvious to many, it's amazing how often one or more are not properly accounted for. Like a chain, the results are only as good as the weakest link.

Evaluation of resistance performance of a motor boat using a high-speed towing carriage.

Jeongil Shin*, Jiman Yang*, Howon Park*, Jaesung Kim*, Hyochul Kim*, Seung-Hee Lee and Jae Moon Lew*****

Abstract

Aftermath of Korean War forbids public access to the most part of the nation's coast until 1988 Seoul Olympic Games. Until now some strategically sensitive beaches are still inaccessible and marine leisure and sports activities are considerably weaker than those based on the land. However, it is foreseeable that the growth of Korean economy and introduction of the 5 days a

week working system will accelerate the growth of marine leisure activities and businesses. In an effort to promote marine activities, recently a high-speed powerboat made of fiber-reinforced plastics for family use has been developed with funding from the Ministry of Maritime Affairs and Fisheries of Korea.

The resistance characteristics of the boat have been tested at the towing tank of the Seoul National University. The use of Froude's similitude law may encounter limitations if applied in estimating the resistances of high-speed boats since an ordinary towing tank may be limited in length and carriage speed. Proper instrumentations for efficient data acquisition have to be devised as well. A high-speed carriage has been designed to circumvent the problems. A lightweight cantilever type towing carriage has been installed on the wall of the towing tank. The wireless devices appropriate for data acquisition during high-speed towing tests have been devised also and the integrated system has been validated through a series of comparative tests. With the new carriage system, a series of model tests have been performed to investigate the hydrodynamic properties of the powerboat and compared to the sea trial results.

On the development of a small multi- hull pleasure fishing boat.

Seung-Hee Lee*, Young-Gill Lee*, Jae Wook Lee* and NamChul Kim**

Abstract

Hull forms and their hydrodynamic characteristics of the multi hull ships including catamarans and trimarans are extensively studied both experimentally and numerically. The spacing between main hull and outriggers and the longitudinal location of the out riggers as well as the shallow water behaviors are carefully studied. Model tests are done at the towing tank of the Inha University and an Euler solver is utilized for the numerical simulations. The results are cross examined to find the optimal size and locations of the outriggers to improve both the motion and resistance characteristics.

A 12 m long 9.77 ton class catamaran has been developed and several ships have been already produced and deployed as pleasure fishing boats in the west coast of Korean peninsula. The boats are made of fiber reinforced plastics and equipped with a pair of 280 hp diesel engines and water jet propulsion systems and the maximum speed exceed 25knots after fully loaded. The results of the sea trials are compared to those of model tests. A trimaran having a displacement of 7.0 ton is now being under development at the CTYS, Inha University. The boat will be used also as a pleasure fishing boat in the vicinities of small islands near capital areas and the stability and motion characteristics as well as the speed will be carefully examined in the development stage since the most of its customers would be unacquainted to the marine environment.

Desarrollo y construcción de un velero clase Mini 6.5 m para la regata Mini-Transat 2005

Ronaldo Fazanelli Migueis[1], Fernando Sampaio Amorim[2], Alexandre Teixeira do Pinho Alho[3], Rafael Botelho Duarte Coelho[4], Ivan Neves Porciúncula[5], Eduardo Fausto dos Santos[6], Beny Pitrowsky Junior[7], Vinicius Almeida Vieira[8]

Abstract

La utilización de nuevas tecnologías en las áreas de hidrodinámica, aerodinámica y compuestos, hizo con que se tornara posible que veleros de pequeñas dimensiones naveguen con mucha seguridad en una regata que pueden cruzar el Océano Atlántico con apenas un único tripulante. La utilización de herramientas como el CAD, CAE, CAM y FEA es hecha para posibilitar un producto final de optima performance, capaz de colocarse entre los primeros lugares en futuras competiciones. El estudio realizado para la definición de la forma del casco, parámetros hidrostáticos y de estabilidad, está basado en observaciones y regresiones

estadísticas de veleros construidos en estos últimos años. Son dos palas, una quilla pivotante y dos orzas, que si son bien concebidas hacen la diferencia en una victoria. La estructura del casco es optimizada con recursos de FEA para garantizar un peso mínimo y una resistencia estructural necesaria, por lo que materiales diversos han sido estudiados y ensayados en laboratorios.

Revised prototype of a single-handed hydrofoil sailing catamaran.

Takeshi Kinoshita[1], Yasuhiro Sudo, Kiyoshi Uzawa and Koutarou Horiuchi

Abstract

A new, high-speed, recreational hydrofoil dinghy has been developed. The concept of the boat, mathematical model used for design and the one fifth and one third model test results were presented in the previous paper [1], and first prototype, i.e., real scale model was reported in another paper [2]. This paper shows test results of a revised prototype model, of which main and fore foils are much improved by means of tank tests. Lift to drag ratios approximately become 15% and 30% better than the first ones, respectively.

In order to obtain the coefficients of hydrodynamic forces acting on the hydrofoils, we carried out force measurement of the hydrofoils for the first and revised modes in the towing tank, and compared the results with values of Wadlin's formula [3], which estimate lift force and drag force of a hydrofoil including the effect of free surface. Tank test results gave corrections to the Wadlin's formula, spray drag's formula of the strut and the drag formula for the connection of hydrofoil and strut. These test results and comparisons should be useful for the design of fully submerged hydrofoils not only of this sailing boat but also of more general high-speed boats.

This revised prototype could be successfully foil-borne in a 50-degree closed-hold wind condition with 50% higher boat speed than wind speed.

"Volador" Un hidrofoil para el récord del mundo de velocidad a vela.

Fulgencio García Hernández *

Introducción

El récord del mundo absoluto de velocidad a vela sobre el agua se encuentra imbatido en 46,5 nudos desde el año 1993. Si bien ha habido embarcaciones que han conseguido navegar por encima de los 40 nudos, e incluso leíamos en la prensa especializada que una plancha a vela ha superado los 45 nudos en mediciones formales el pasado año, otras embarcaciones de la más alta tecnología se han quedado en el camino y, por lo tanto, continúa sin superar la marca que estableciera el tri-casco "Yellow Pages Endeavour" hace ya más de una década. (Figura 1)

En un artículo leído en las XXXVIII Sesiones Técnicas de Ingeniería Naval (Ref. 1) se estudian las claves de la alta velocidad a vela y se pasa revista al estado del arte en la materia. Se estudian las embarcaciones contendientes y se ponen de manifiesto sus aquellas de sus características que ponen límite a su velocidad máxima. A partir de los estudios descritos, se propone un hidrofoil tipo canard de 12 metros de eslora, con planos superventilados, propulsado por una vela rígida de 19 metros cuadrados. De acuerdo con cálculos basados en la teoría y en datos procedentes de diversas publicaciones, este hidrofoil podría navegar a 3 veces la velocidad del viento real, y tendría estabilidad para hacerlo en vientos de hasta 20 nudos, sin estar limitado por la cavitación de los foils. Por lo tanto, esta embarcación sería potencialmente capaz de batir el récord actual de velocidad a vela sobre el agua.

A la busca de un esponsor para el proyecto, la Presidencia y la Dirección Comercial de IZAR asumieron el patrocinio del mismo, estableciéndose un programa para el desarrollo del

proyecto, construcción del hidrofoil e intentos de récord. Los patrocinadores pusieron la condición de que se hiciesen los cálculos y ensayos previos a la construcción del hidrofoil que asegurasen sus posibilidades de éxito en cuanto a buen funcionamiento y capacidad para lo que se proyectaba.

En el presente artículo se pasa revista de nuevo en forma resumida a las claves de la alta velocidad a vela, y al proyecto de detalle del hidrofoil, denominado "Volador". Se informa de los ensayos realizados en el Canal de El Pardo para comprobar el funcionamiento de los foils y de los cálculos aerodinámicos (CFD) y se comparan la predicción original de velocidad con la resultante de nuevos cálculos realizados con los datos de los ensayos.

Application of RANS CFD calculations to the design of sailboat hulls.

Philippe Pallu de la Barrière [*], Jérôme Védrenne [*]

Introduction

For many time, America's Cup projects have put efforts to develop and to use CFD codes to perfect hull shape. Those codes are used to compare candidate design performance and to analyse flow around a hull in order to improve its shape. Tools that have been commonly used for fifteen years are potential flow code, with or without additional boundary layer calculation, which do not take properly into account non-linear and viscous flow effects where tank testing gives more precise global results but few indications about flow properties. The "box" rules of IACC, the experience from previous editions and the high level of the competition lead to look for small differences between hull shape inducing small, but sensitive, drag differences. For the America's Cup 2003 campaign, RANS (Reynolds Averaged Navier-Stokes) codes with free surface were for the first time available with reasonably good computational time and practical efficiency. The authors were involved in the design team of the French challenge for the America's Cup and have put efforts to find useful applications of the RANS code ICARE for studies of hull shape performance. ICARE code is a RANS solver, developed at Ecole Centrale de Nantes, for calculation of three-dimensional, turbulent, incompressible, unsteady, free surface flow around a hull. It has been used to evaluate and to compare canoe body only performance in steady state, with free trim and sink and to explain some drag differences by the local behaviour of flow like vorticity, helicity or dynamic length. Then, we will describe the method used to practically get consistent results on a large number of hulls, discussing mesh size, accuracy and computational time. Then we will show, using example of IACC and Open 60' hulls tested in tank test, how can RANS CFD improve results compared to those delivered by potential flow calculation. We will also show for those precise cases how analysis of local parameters can provide a guideline to improve performance of the hull shape.

Hydrodynamic study of a canting keel based appendage configuration.

C. López Pavón[1], R. Zamora Rodríguez[2], L. Pérez Rojas[3]

Abstract

Once the new rules that govern the design of VO70 class has been published, the necessity arises of evaluating the different configurations that this type of boats will adopt. These alternatives are mainly based in the incorporation of a canting keel to increase the righting moment of the boat, therefore to reach greater speeds. The handicap of having a greater righting moment is the lost of lateral force by the reduction of projected lateral area at the keel. To compensate this and to avoid excessive yaw angle, several solutions are being considered. In this article, the two most probable configurations to be adopted by the fore coming VO70 class will be evaluated.

Comportamiento en la mar de un Copa América: estudio meteorológico Valencia vs Hauraki.

E. Carrillo, A. Marón, J. Valle [*]

Resumen

Tras la selección de Valencia como sede de la próxima edición de la Copa América nace un nuevo reto para los diseñadores: el cambio de las condiciones del campo de regatas.

El primer trabajo a realizar debe ser un estudio de las condiciones meteorológicas de Valencia, enclavada en el Mar Mediterráneo, y compararlas con las que se dan en el Golfo de Hauraki (Auckland – Nueva Zelanda), para con ello intentar aprovechar gran parte de las investigaciones realizadas al respecto en las últimas ediciones.

En el presente trabajo se va a llevar a cabo una comparativa previa entre ambas zonas de regatas desde el punto de vista meteorológico (centrado en el parámetro viento) y de estado de la mar (oleaje).

Tras ello se evaluará la validez de los estudios de comportamiento en la mar para veleros Copa América realizados para anteriores ediciones y la importancia que pueden llegar a tener investigaciones similares para la próxima edición.

Abstract

Since Valencia was selected to host the next America's Cup edition a new challenge for the designers has born: the change of the regatta course conditions.

The first step has to be the study of the meteorological conditions of Valencia, in the Mediterranean sea, compared with the conditions of Hauraki Gulf (Auckland – New Zealand) in order to use as much results as possible from the previous America's Cup editions.

In this paper a previous comparison of the meteorological conditions (focused on wind) and the sea behaviour (waves) in both regatta courses will be presented.

Finally, the validity of the seakeeping studies done in the previous America's Cup sailing yachts will be evaluated, showing the importance of using similar investigations in the next edition.

Reynolds-Averaged Navier-Stokes in an integrated design environment.

Dr. Richard Korpus*

Introduction

Computational Fluid Dynamics (CFD) has long played an important role in America's Cup Class yacht design. As the class matures, however, it becomes increasingly difficult to improve on performance. Boat speed differences smaller than 1% now often separate competitors, and designers have to search ever harder for finding even small gains. More accurate tools are needed to identify these small differences, and the burden often falls on Reynolds-Averaged Navier-Stokes (RANS) technology.

While RANS is still considered state-of-the-art CFD, it's essentially the only practical choice. Simpler flow modeling techniques, such as panel codes, are incapable of resolving many of the flow features that affect small performance differences (e.g. form drag, separation, vortex wake details). Model tests are time-consuming and often quite expensive. More complex CFD models (such as Large Eddy Simulations) are not yet sufficiently practical for yacht Reynolds numbers or time-critical design environments. It's important to realize, however, that RANS is only a supplement to existing design techniques, not a replacement. There's no need to apply

RANS when a panel code will do, and model tests are still needed to keep designs grounded in reality.

But while faster computers have made RANS analyses *possible*, most applications to date fall short of being *practical*. If an America's Cup designer is to improve boat speed, he or she must analyze hundreds of design alternatives -- not the few isolated samples usually associated with RANS [2, 9,14][1]. And even when a large number of flow analyses is available, the measures-of-merit required to rank designs are not obvious RANS outputs like flow detail or drive force. RANS codes have to be coupled to more traditional design decision tools such as Velocity Prediction Programs (VPP's).

Three crucial challenges remain before RANS can be applied in the practical design arena. First, how can a level of throughput be achieved to rank hundreds of design options? Second, how can it be reliably insured that RANS will accurately resolve small design differences? And third, how can RANS be seamlessly integrated with traditional design tools?

Meeting these challenges requires a specific blend of RANS technology. High throughput, for example, requires more than a fast computer. It requires simple yet general grid generation capabilities. The flow solvers must exhibit high degrees of robustness so that time is not wasted debugging unstable runs. A system is required to automate geometry handling, grid generation, and RANS analysis. Only by "removing man from the loop" can high throughput be achieved. Similarly, resolution of small differences requires a high level of grid repeatability, discretization accuracy and turbulence model sophistication.

A RANS package meeting these goals was developed for Oracle/BMW's 2003 America's Cup challenge. The package includes automatic grid generation utilities (both above and below the water), overset grid processors, RANS code interfaces, run management utilities, and automated post-processors. The system is integrated using a series of UNIX shell scripts, and installed on a 64-processor HP/Compaq alpha cluster. Production levels up to 400 three-dimensional (3 million point grid) RANS analyses per month were obtained.

Oracle/BMW utilized the resulting system for a number of functions within their design program. Specifically, RANS was used to:

- Rank design options based on performance;
- Analyze a greater number of options than could be tested or built;
- Verify performance gains too small to test;
- Guide a design process by linking perform-ance to flow, and flow to design feature;
- Guide the allocation of R&D design, build, and test resources.

Performance differences as small as 0.1 seconds per mile (0.03%) were resolved, and 11 seconds per mile (3%) cumulative improvements to boat speed were identified

This paper describes how these levels of productivity and accuracy were achieved. It documents the detailed technologies brought to play, and the steps taken to implement them in the design process. Specific demonstrations are given in each area where RANS played a key role: and include examples from sail, mast, appendage, and hull design. In each case, descriptions are given as to how flow data was used to improve boat performance. The paper closes with a discussion of the expanding role RANS is expected to play in the future of design.