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A novel full scale laboratory for yacht engineering research

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ABSTRACT

This paper presents an overview of the Lecco Innovation Hub project and in particular to the Sailing Yacht Lab project a 10 m length sailing yacht which aims to be a full scale measurement device in the sailing yacht research field. A description of scientific framework, measurement capabilities as well as of the principal design, building process, project management and commissioning is provided with some examples of preliminary collected data obtained during the first sea trials. Finally an overview of the ongoing project tasks and future project developments is provided including potential research and knowledge achievements for sailing yacht research field.

1. Introduction

This paper presents an overview of the Lecco Innovation Hub project and in particular of the Sailing Yacht Lab project a 10 m length sailing yacht which aims to be a full scale measurement device in the sailing yacht research field.

Lecco Innovation Hub (LIH) is a dedicated nautical research and training center at the Lecco Campus of the Politecnico di Milano university aiming to encourage the transfer of technology to and from the nautical and related sectors.

Lecco Innovation Hub consists of two basic entities:

- The Sailing Yacht Lab (SYL), a 10 m length sailing yacht fitted with instruments for acquiring data on the behavioral variables of the boat and her components at full scale to support a scientific approach to design and research activities related to sailing yacht design and performance
- The S.Ma.R.T. (Sustainable Marine Research and Technology) laboratory is designed to support nautical industry in meeting the increasing pressing demands for innovation and sustainability. Specific lines of research are the analysis and assessment of the entire life cycle (LCA) of nautical products, design for disassembling, experimentation with new materials for construction and fitting out, ergonomics, safety and comfort on board, interior lighting and the improvement of the quality of air.

In addition to these, there are the research infrastructures present in other sites of the Politecnico di Milano, such as the Wind Tunnel – Europe's largest – at the Milan Bovisa campus (Fossati, 2006).

Aim of this paper is to provide an overview of the Sailing Yacht Lab project: a brief summary of the origin and early evolution of the vessel's design will be given, along with a description of principal design and performance criteria.

Design, building process, project management and commissioning will be described in the following; the measurement capabilities and data acquisition procedure will be described in details.

The project is still in progress; in order to put into perspective research the capabilities provided by this new available tool some examples of preliminary collected data obtained during the first sea trials are reported and discussed.

Finally an overview of the ongoing project tasks and future project developments is provided including potential research and knowledge achievements for sailing yacht research field.

2. Full scale testing

The ability to predict the maximum potential performance of a racing sailboat is a strong asset yet demanding verification of both experimental results and numerical derived data.

First methodical approaches for calculating yacht performance came not before the Thirties as demonstrated by the GIMCRACK

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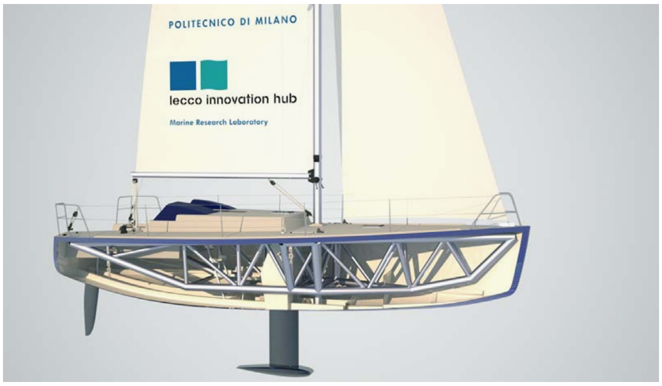

Fig. 1. Sailing Yacht Lab concept.

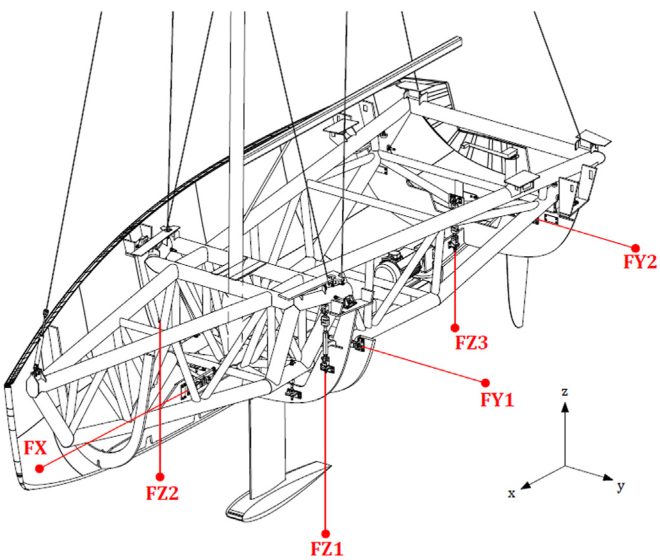

Fig. 2. Load cells arrangement.

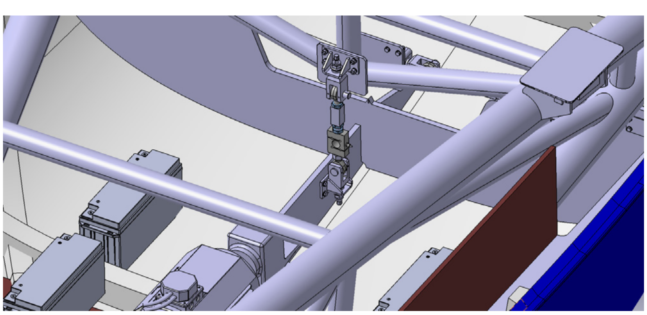

Fig. 3. Load cell–frame connection detail.

case when Olin Stephens and the Davidson Laboratory at Stevens Institute developed a full experimental program combining full scale sailing testing and tank tests on scale model with the intention of determining sail coefficients and predicting performance of sailing vessels.

The estimation of a sailboat's potential speed based on its design alone began in the 1930s with sea trials of GIMCRACK a 34′-6″ LOA, 23′ LWL low-freeboard day-sailer designed by Sparkman and Stephens.

Since 1936 when Gimcrack sailing performances were measured at full scale, the most of such tests have been performed in the frame of America's Cup boats technical development aimed at comparative analysis.

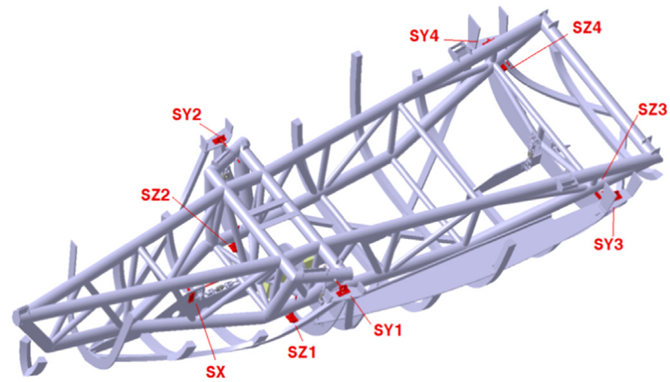

Fig. 4. Safety rods arrangement.

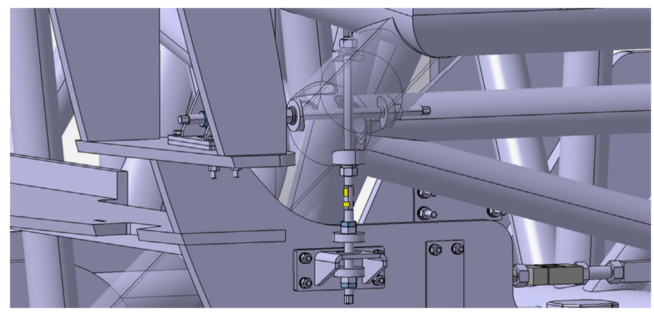

Fig. 5. Safety rod concept.

Olin Stephens and the Davidson Laboratory at Stevens Institute successfully used Gimcrack to correlate scale model results with full-scale sailing testing, deriving the longitudinal driving force, aerodynamic side force and heeling moment. The correlation constants between model and full-scale performances derived by these studies became known as the Gimcrack Coefficients (Davidson, 1936). The Gimcrack Coefficients were the first known comparison of this type, proving to be a significant breakthrough in the science of sailing yacht performance prediction.

The scientific data currently available to designers and builders was derived from studies based on numerical or experimental data generally obtained from scale models, prototypes or material samples analyzed in artificial environments, such as wind tunnels, towing tanks or test benches.

With particular reference to sail aerodynamics, the methods currently used to attempt to characterize a sail plan are tests either in wind tunnels on scale models or on full size boats and the use of computational fluid dynamics.

At present numerical methods provide sound results for upwind and close reaching sailing but are still under development for downwind sail design. This is because the numerical techniques developed for the aeronautical sector can be applied to sails used for upwind sailing because these behave like thin airfoils affected only to a limited flow separation, while it is much more complex to solve the flow pattern that develops around a spinnaker or gennaker where the significant amount of curvature leads to large areas of flow separation. In addition downwind sail aerodynamics is actually affected by the aeroelastic mechanism: the “flying” shape of an offwind sail under real sailing conditions is determined by the pressure distribution acting upon the sail, which are not depending only on wind strength and direction but also from structural properties and sails trim controls acting upon the edges and corners of the sail as well as on forces applied to the rig and sail. All of these factors contribute to the virtually infinite number of flying shapes over the range that a particular sail can achieve under actual sailing conditions and differently from the upwind sails this is particularly