**Hydrodynamic characteristics of innovative high-speed vessels**

*Caratteristiche idrodinamiche di veicoli marini veloci innovativi*

**Funding:** National (Italy)

**Duration:** Nov 2003 - Nov 2005

**Status:** Complete with results

**Background & policy context:**

During recent years there has been an increasing interest in high-speed marine vehicles both on very short-distance or local areas and on medium-range routes. Also, for such ships non-conventional hulls, both with single hull and with more hulls, have been proposed, especially for passengers and car transportation. This research intended to study problems regarding hull resistance, generated wave pattern, seakeeping and, in addition, some aspects of stability for three typologies of high-speed craft with the aim mentioned above.

In addition to specific problems, the design of high speed hulls involves a series of themes that, notwithstanding those still subject to studies and research in general ship hydrodynamics, are to be further verified and adapted in this particular field of application. Interest in the above is confirmed by several scientific papers that appear in international literature and in conferences. In fact many topics are still to be investigated in this field, and appreciable uncertainties remain about the evaluation of the hydrodynamic, safety and operating characteristics of the various typologies of these high-speed marine vessels.

Consequently, uncertainties exist also about the choice of most suitable ship type for given distances and operating conditions. Presently, among high-speed marine vehicles, monohulls and catamarans are mainly employed.

In the last years, marine transportation with larger fast ships has expanded also on national and Mediterranean medium-range routes, especially with monohulls. Unresolved aspects or, at least aspects requiring deeper investigation, still remain regarding prediction of hull hydrodynamic resistance and of motion in waves for high-speed ships. Studies and proposals for non-conventional high-speed marine vehicles have been published in which the trimaran hull seems to be the subject of a recent appreciable international interest. Also a pentamaran hull concept for passenger and vehicles transportation has appeared very recently. For each of these two typologies, the published papers do not yet provide a sufficiently broad and systematic basis of information about their hydrodynamic behaviour, in fact complete hydrodynamic investigations have not yet been disseminated, especially as regards seakeeping. Also safety has a fundamental importance, and it is also linked to the hydrodynamic behaviour of these ships.

**Objectives:**

The objective of this research was to investigate the hydrodynamic characteristics of three multihull typologies for a fast marine vehicle to be employed on Mediterranean routes on mean distances, for passenger and vehicle transportation. At present time, monohull and catamarans are the most applied solutions for fast marine vessels.

In this research, therefore, the purpose was to evaluate and compare, at the same operational conditions, the hydrodynamic resistance and the seakeeping performance of a trimaran hull, of a pentamaran hull and of a peculiar catamaran (here indicated as BULBCAT) fitted with a central immersed body sustained by a surface piercing strut, with the aim of reducing ship motions in sea waves.

Within such general targets, a study articulated in several parts was planned, in order to achieve the
following purposes:

- to collect a significant database of experimental test results regarding hydrodynamic resistance for the selected typologies, even on different scale models
- comparison purposes among the considered marine vessels
- evaluation of particular problems in still water (related to the scale effect, data transfer to real scale etc.) that arise for the various vessel types and that are increased by the high speed
- to collect a set of seakeeping experimental test results for the three hull typologies, both in order to obtain first preliminary database for the comparative evaluation of the three vehicles, and for the validation of the numerical methods
- to obtain indications, comparisons and conclusions on the possibility to evaluate and assess the aspects relevant to the behaviour of ships in waves for the different hull typologies
- to achieve a methodology that permits evaluations on the wave pattern at the far field which could represent a significant term of comparison to be considered while selecting a marine vehicle, especially if the operational route is, for a considerably long part, near the coast
- to improve, enhance and adapt numerical methodologies for studies about hydrodynamic resistance and seakeeping performance applied to the considered high-speed marine vehicles
- to supply some indications in terms of safety of the considered high-speed vehicle in terms of stability and in terms of seakeeping performance.

Methodology:

The research was carried out according to the following main phases and tasks:

- Definition of geometry of hull forms of the involved marine vehicles: two hull forms for the trimaran hull, two hull forms for the catamaran hull and one form for the pentamaran hull. The models were built in two scales. Resistance tests were carried out in the three towing tanks of the research units.
- Resistance tests of the small scale models were carried out dividing the tasks between the smaller towing tanks of Genoa and Trieste. In Naples, resistance tests of all the models on a larger scale and on some models in small scale were carried out.
- Seakeeping experiments in regular head waves were carried out in Trieste on the small scale models (about 2 m long). Some roll experiments in transverse waves were also carried out.
- Configurations of the vehicles (position of side hulls of the trimaran and of the catamaran, position of the bulb of the catamaran) have been systematically varied.
- Starting on previous experiences, numerical methods based on boundary elements have been specially studied and developed for evaluating resistance and motions of the considered vehicles. The particular vehicle configurations have in fact required remarkable extensions of the algorithms, the generations of meshes and the production of computer codes.
- Optimisation methods have also been used in some cases to determine the best configurations.

Parent Programmes:
PRIN calls 1999-2005 - Research projects of national relevance

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Partners:
Italy:
University of Genova

University of Genova - Dipartimento di Ingegneria Navale e Tecnologie Marine

Organisation: (DINAV)
Address: Via Montallegro, 1
Zipcode: 16145
City: Genova
Contact country: Italy
Telephone: (+39) 10 353 24 27
Fax Number: (+39) 10 353 21 27

Key Results:

A systematic set of experimental results on resistance was realised for two possible trimaran forms and
for a pentamaran form in two different scales and a systematic set of experimental results on resistance was realised for two possible catamaran forms also considering forward central bulbs in two different scales.

A collection of experiments about heave and pitch motions in regular head waves as well as added resistance has been realised for some significant configurations of a trimaran hull, of a pentamaran hull, and of catamaran hulls fitted with a forward central bulb. In addition, roll experiments in transverse waves were carried out. It is believed that the results from these set of experiments could form an interesting reference for people involved in studying hydrodynamic characteristics of high-speed multi-hull marine vehicles.

The best position of the tested trimarans as far as resistance is concerned was found when the stern of the side hulls is aligned with the stern of the main hull, with the side hulls transversely positioned at about 10% of the length of the trimaran. Different bulb forms and positions have been investigated on the bulb-catamaran. Minor differences have been noted in resistance of the bulb against the non bulb-catamaran. The round bilge hull form allows a reduction of residuary resistance for lower Froude numbers. In some configurations and for some Froude numbers the central bulb allows reductions on vertical movements. Roll experiments in beam regular waves on some configurations of the round bilge trimaran and on the pentamaran hulls have evidenced the possibility of critical situations regarding safety in that roll motion could reach dangerous values.

The complementary application of numerical methodologies coupled with the foregoing experiments has evidenced their utility in defining the characteristic regarding the resistance and the behaviour in waves of multi-hull ships. Their potential for optimising the configuration of multi-hulls has been confirmed by the experiments. In the case of the catamaran hull it has turned out that a central bulb generally contributes in the reduction of the vertical motions but has not significant effects on roll motion. Among the considered vehicles, the hard chine trimaran turned out to be the best vessel as far as resistance is concerned.

It should be noted that the marine vesse

**Technical Implications**

1. Although this research has systematically considered different configurations of trimaran hulls in two basic forms for the main hull (a round bilge and an hard chine hull), it could be suggested to study other hull forms and other dimensional parameters.
2. Other forms and dimensions for the side hulls of the trimaran should also be studied.
3. Seakeeping behaviour of trimaran hulls should be studied systematically both by experiments on different configurations and by numerical methods which should be adapted to the particular situation of multi hull ships.

**STRIA Roadmaps:** Vehicle design and manufacturing  
Water transport (sea & inland)  
**Transport mode:** passenger transport, freight transport  
**Transport sectors:** Passenger transport, Freight transport  
**Geo-spatial type:** Network corridors