LIUTO

Low Impact Urban Transport water Omnibus

A solution for water city transport

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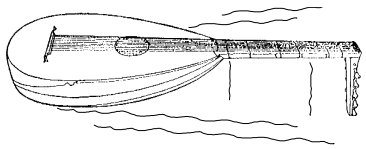


L I U T O - L o w I m p a c t U r b a n T r a n s p o r t w a t e r O m n i b u s

INTRODUCTION

In the spring of 1995 ACTV, the company that manages the public transports in the city and province of Venice, presented to the European Commission (DG XII - Research and Technological Development) a project proposal that addressed the development of a new waterbus within its objective of renovating its water transport fleet.

The proposal, presented within the Brite-Euran programme (Industrial and Materials Technologies), was approved in the summer of 1996 (Project Nr. BE 95-1782).

*The project, that commenced on the 1st September 1996 is called **LIUTO** (**L**ow **I**mpact **U**rban **T**ransport water **O**mnibus), and has the objective of studying, designing, material testing, model testing in test basins, constructing and field testing of an operative prototype of an innovative hull and propulsion system.*

OBJECTIVES AND EXPECTED RESULTS

The objectives that the LIUTO project set itself and the innovations that have been studied and applied can be summarised as:

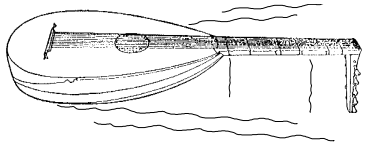
- *Reduced hydrodynamic impact (wave and wash generation from the propusion system) associated with an increased manoeuvrability thanks to the research into the hull design and the propulsion system, as well as the development of technologies for the analyses of these phenomena.*
- *Use of composite materials for both the hull and the propulsion system, with particular characteristics for the resistance to the operative conditions (impacts, vandalism, solar radiation) as well as reduced maintenance costs.*
- *Increase in comfort, through dedicated studies of the deck space available, of the ventilation of the internal areas, and of the reduction in noise and vibrations, both due to the characteristics of the materials used, and due to the hybrid power generation system foreseen.*

LIUTO has the objective of illustrating both the environmental and economic advantages possible with technologies which in part already exist, for example composite materials, but to date have not been utilised in such severe applications as urban water transport, and in such a delicate and valuable context, from both a historic and artistic point of view, as is Venice and its lagoon.

The results of the project shall permit two challenges to be dealt with: firstly the increasing demand on water transport services without increasing, and possibly diminishing, negative impacts on both the environment and the local population; and secondly the possibility of exporting to other European countries interested in water transport the technologies developed and tested on a full scale prototype. In particular Germany and Holland have been identified as countries where the particular problem of erosion caused by transport on internal canals is considered of prime importance.

FORESEEN USE AND MAIN CHARACTERISTICS

The LIUTO waterbus has been studied for the diverse services of ACTV's fleet, which exceeds 100 vessels having a capacity between 180 and 210 people, with particular attention to the challenges of the lines 1 and 82, that have fundamentally different characteristics. The first entails navigation principally within the Grand Canal, with constant stops and accelerations, but at a reduced speed, while the second is mainly around the outskirts of the city and requires elevated performances and efficiency at higher speeds.



These requirements, which are in part contradictory, have required careful analysis of the alternative solutions available, for the naval architecture, the propulsion system and the power generation.

The overall dimensions of LIUTO are not substantially different form those of the current water busses, although the hull lines and the super structures are significantly dissimilar.

An important innovation that has been developed in a parallel research project financed by ACTV and assigned to ANSALDO SISTEMI INDUSTRIALI via public tender, is that of the development of a hybrid diesel electric power generation system. With this system, which has been the object of study for a number of years both by the automobile industry and by ACTV for this type of application, the propulsion system is run by an electric motor that is powered by battery packs or an inverter. These are charged in turn by a diesel generator that runs at constant speed. The system is illustrated in Figure 1.

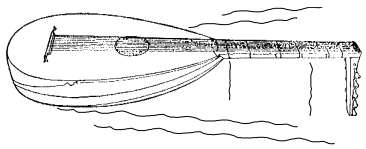
The benefit that is achieved by this system is to run the diesel engine at its optimum efficiency level and thus minimise its pollutant emissions. In addition in this manner both noise and vibrations generation are minimised with a resulting increase in comfort for the passengers. This system is also intrinsically highly reliable thanks to its functional redundancies.

COMPANIES AND INSTITUTIONS THAT HAVE CO-OPERATED IN THE PROJECT.

The organisations that have co-operated in the LIUTO project are:

- *ACTV of Venice, who has been the main promoter, generating the technical objectives in the proposal phase and then acting as co-ordinator during the project. In addition ACTV has committed itself in both technical and economic terms to the completion of the prototype into a navigating water bus, with investments in the hybrid system and in the ship outfitting (see Figure 2);*
- *The Department of Naval Engineering of the University of Naples, who developed the hull lines and performed the first basin tests (see Figures 3 and 4), as well as being responsible for the analysis of the hydrodynamic impact on the full scale prototype.*
- *SCHOTTEL-WERFT, JOSEF BECKER GmbH & Co. of Spay/Rhein (Germany), well known constructor of azimuthal propulsion systems, who had the responsibility, together with SVA of the study and construction of the new propulsion system (see Figure 5).*
- *SVA - SCIFFBAU VERSUCHSANSTALT POTSDAM GmbH of Potsdam (Germany), naval research institute that specialises in propulsion systems and performed the numerical simulations as well as the scale tests of the propellers (see Figure 6).*
- *MARIN - MARITIME RESEARCH INSTITUTE NETHERLANDS of Wageningen (Holland), world famous naval and maritime research institute, that had the responsibility of optimising the hull lines through numeric modelling and of performing the basin tests on large scale models, complete of the propulsion system (see Figures 7 and 8)*
- *INTERMARINE SpA, of Sarzana (Italy), well known constructor of naval vessels in composite materials, to date mainly in the field of defence (mine hunters), who performed the material tests, the structural design and constructed the prototype of the vessel (see Figure 9).*

The Project Manager, nominated by ACTV, is Attilio Brighenti, Systems & Advanced Technologies Engineering, who co-ordinated the technical activities of the project partners, and liased with the European Commission and the other projects financed within the same programme for the marine sector, in order to integrate the knowledge developed in parallel.



RESULTS OF THE PROJECT

The characteristics of LIUTO shall be such as to allow efficient and environmentally friendly operation in a variety of service lines, both across the city and between central Venice and the nearby islands. The reference lines will however be n°. 1 and n°.82, as cited, in the present official services timetables.

The LIUTO design and main test conditions have been defined considering three basic speed requirements, in calm waters and no wind conditions, at defined water depths:

V_1	urban speed	5.94	knots	in	4.5	m w.d.[1]
V_2	max full load speed	10.0	knots	in	10	m w.d.
V_3	max half load speed	10.8	knots	in	10	m w.d.

The above maximum speed V_3 is lower than the target value (12 knots), due to the confirmed speed limits in the lagoon waters, which would render that performance of no benefit and much constraining the design. Nevertheless the model tests have been performed and will be repeated on the prototype up to that value to verify the potential, power and impact of the M/b at this speed.

The improvement of LIUTO's hydrodynamic behaviour over present M/b's is principally achieved by increasing the overall length (from 23 to 25 m), and by improving the hull lines to generate low residual resistance and wave generation, with its consequent impact on the beds and sides of the venetian canals. The weight reductions obtained by the use of composite material shall allow a slight increase of the number of passengers, to 230. The wider space available allows a remarkable increase of comfort, with the number of seats to be increased from the current 75 to 100.

The innovative LIUTO design has been developed compatibly with the existing infrastructure (boarding pontoons dimensions and height) and crew composition and qualification, to facilitate its ingress into routine service

Today all the activities of the project have been completed, including the comparative tests between the LIUTO prototype and a conventional waterbus, in order to verify its actual performances, in particular as regards the hydrodynamic behaviour. These tests confirmed the expected results, previously obtained in the model tests.

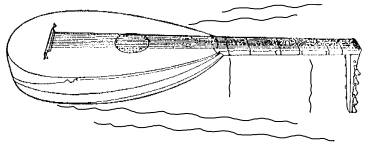
The first results obtained by the project were the remarkable success of the naval architecture design activity. These proved the new vessel to have a total and residual resistance at least 25-30 % less than the present ones. Wave making reduction goes with the former, depending on the speed.

A very efficient propulsion system was also developed, with blades made in carbon fibres composite, exceeding 60 % efficiency in all useful ship speeds, which is an improvement of 15% on standard propellers in similar conditions. Therefore, the delivered power at the maximum speed and displacement specified for LIUTO will not exceed 70 kW.

The structural material tests on the fibreglass and the design proved the possibility to satisfy severe operating conditions with low lightship weight even at maximum displacement, considering the greater overall length of the vessel.

As regards the design tools, the extension and validation of the RAPID computer fluid dynamics code, developed by MARIN, for shallow restricted water conditions was successfully obtained,

[1] Although for speed and power performance evaluation the shallowest water depth of reference is the above stated 4.5 m, the minimum operational water depth shall be 2 m.



particularly for the highest, most important speeds. The SVA's propeller code VORTEX was also successfully used and upgraded in the prediction of the twin rotors propulsion system.

In parallel the feasibility and efficiency of the hybrid energy system was demonstrated, that reduces the fuel consumption and the exhaust gas pollution, while leaving unchanged the power available to the propeller, as necessary for safe manoeuvring.

On the basis of the experience gained during the project, an in depth study has also been performed of the relative costs of LIUTO type vessels compared to current steel or aluminium vessels with traditional propulsion systems. This study has illustrated that notwithstanding the greater capital cost that a LIUTO type vessel shall incur, the life cycle cost considering an operative life of 12 years shall in fact be of the same order of that of a traditional vessel.

It can be concluded that the key objectives of the project have been achieved. Now the LIUTO prototype itself is operative and available for the regular and rental services managed by ACTV. With the experience gained in its utilization it will be possible to further improve this product, with the aim of achieving the best technical and economical trade-off, both for the end user and the manufacturer, while aiding in the protection of the environment.

This innovative and accessible technology is now available not only for the renewal of the fleet employed for the urban transport service of Venice, but also for the implementation of new water transport services in the World's cities where this option can solve the congestion in land road traffic.