Practical Design of Ships and Mobile Units
M.W.C. Oosterveld and S.G. Tan, editors.

A system for the experimental determination of the hydrodynamic impact of M/Bs operating in Venice.

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The Liuto Project has the main aim of designing the hull of the water bus of the future for the city service in Venice. The project itself must be sided by a series of parallel studies with the aim of investigating into the real impact of the lagoon environment of both the old and the innovative hulls.
The W.P.4.2 has to set up a methodology capable of measuring the main parameters involved in the environmental impact of the operations of the M/B working on the lagoon.
A first campagn of data logging was carried out some months ago and this paper reports the characteristics of the system used for measurements, the tests carried out, the problems arisen during tests to be solved to obtain a reliable measuring system for the final testing.

1. INTRODUCTION: THE PROBLEM OF THE DECAY OF THE LAGOON ENVIRONMENT

The transformation processes of the morphology of the Venetian lagoon have achieved such a level as to require a continuous observation and a recognition of the necessary operations to contrast the decay. The simple rising of the land level, in the last one hundred years, has been evaluated in about 24 cm, which substantially modifies the morphology of the areas [ref. 1].

The environmental damage is a consequence both of long term causes (subsidence, immersion of the shoal areas, modification of the streams etc.) and of temporary or artificial situations generally due to human presence, including the destruction of the submerged walls surrounding Venice.

In particular, the effects of the radiated waves due to the passing of motor boats in the canals are well known together with those associated to the operations of vessels having transversal dimensions similar to the ones of the canal they pass through.

Since the necessity to limit the damages of the bank erosion has been always felt, the phenomenon of the radiated waves in the canals of the Venetian lagoon has been studied for a long time. In the 1907, the foundation of the Magistero alle acque (Magistrate of the Waters) and of the *Ufficio Idrografico* (Hydrographic Office) [ref. 1,2], with the aim of inquiring into the causes of the changes of the lagoon and of following its evolution, showed the interest and experience of the Venetian people as regards the lagoon conservation. More recently, with the help of new technologies for the monitoring of phenomena connected to the evolution of the lagoon, the *Commissione Moto Ondoso* (Wave Motion Committee) was created ad hoc, with the task of studying the genesis, consequences and possible solutions of such undesired and serious phenomenon for the devastating effect it can generate. The presentation of the data acquired [ref. 1, 3, 4, 5] clearly showed that the main factor is the speed.

2.. THE ENVIRONMENTAL IMPACT DUE TO THE OPERATIONS OF THE M/B IN THE VENETIAN LAGOON

The lagoon navigation causes two kinds of damages to the submerged structures.

1. The waves radiated by hulls and propellers interfere with the walls generating the wash effect; because of the permeability of the bricks, with the passing of the wave top, the structure gets filled with water then drained when the bottom passes [ref. 2]. This creates a

pulsating action that draws out incoherent materials included in the structure. With time, the less stable elements are first separated from the solid parts and then drawn down by the water with the consequence of weakening and emptying the structures, thus letting the water pass through, with all the imaginable consequences.

2. The perturbations of speed and pressure, connected with the fluid streams generated by the propellers, create a consumption of the material of the submerged walls that, in time, may become relevant. In particular, the component of the velocity in the direction normal to the wall has an undermining effect because of the crash; the tangential component draws out the less coherent material by friction, once it has been weakened by the first effect.

The two phenomena have a different nature and create different effects on the surrounding environment. The wave motion by itself does not create translation of material since the trajectories of particles are orbital and only the perturbation has its own celerity. The effects of radiated waves are sensible even at remarkable distances from where the vessel passes and therefore can influence also far away areas. Therefore, such phenomenon is basically connected to the vessel navigation.

The perturbations created by streams are destined to dissipation due to the friction and can also last in time due to the principle of the conservation of the angular momentum (applied, in this case, to the vortexes created by the fluid stream). The latter case regards the manoeuvring of the vessels while the propeller remains in proximity of the submerged walls for a relevant time emitting the flow in their direction.

3. THE ACTION OF THE LIUTO PROJECT

The main goal of the LIUTO project is to realise an innovative water bus having a reduced environmental impact. The vessel in project should be qualified by defining its hydrodynamic characteristics and by the impact of its operations on the surrounding environment. The task of the WP 4.2 is to determine a valid criterion for the evaluation of one of the effects of the service of the M/B hull and propulsion system to be kept under control: pressure and wave perturbations whose negative influence damages the integrity of submerged walls surrounding the lagoon city.

In order to compare the behaviour of the present motor boats and LIUTO, it is necessary to determine some test procedures which would allow a real comparison between the influences of the two hulls — and related propulsion systems — on the environment they operate in; such procedures, practically, should analyse the behaviour of such elements showing the aspects of the hydrodynamic impact on submerged walls and foundations.

4. THE METHODOLOGY OF THE TESTS CARRIED OUT IN JULY, 1997

The first campaign of data logged carried out in Venice (July, 1997) was destined to a first screening of the possibility of registering data about the environmental impact of the operations of water busses; in particular, these tests had to screen the operations of the old hull working in the lagoon. The main parameters involved in these phenomena were determined in:

- velocity of the water;
- pressure of the water;
- mean value of the water (due to the tide) in the period of the tests;
- position of the ship;
- speed of the ship.

In order to log these parameters, commercial sensors were used except in the case of the water velocity; indeed, for the foreseen field of velocity of the water (coping with the budget available for this research), no commercial sensors can meet the required aim. Thus, special sensors - based on a plate moved by a sphere sensitive to the flow of the water - were set up capable of giving a signal proportional to the velocity of the water in the zone corresponding to the centre of the sphere.

Of course the tests were set with the aim of simulating the real operating conditions of a water bus in service.

Thus, tests included:

- *tests in canal* i.e. measurement of perturbations due to the passage of water busses and other kinds of vessel in the

canal; this test allows the determination of the standard perturbation in the canals due to the normal traffic;

- *tests in parallel route* i.e. measurement of the perturbation due to the passage of a water bus in protected waters (a canal without traffic, where the only perturbation present is due to the tested M/B); in this case the M/B is controlled from the point of view of its position and speed;
- *tests during manoeuvring* i.e. evaluation of the perturbations due to the operations of the M/B during manoeuvres (mooring and unmooring)

5. THE RESULTS OF THE CAMPAIGN OF TESTS CARRIED OUT IN VENICE (JULY 1997)

Before the tests an evaluation of the possible values of the parameters involved in the phenomena under study was carried out; more details are available in [ref. 6]. The velocity and wave height sensors were set on a support consisting in a pole driven in the bottom of the canal; the sensors of velocity of water measured the longitudinal and the transversal component of the velocity of the water at a depth of about 0.1 m; the capacitive probes were set on the same pole at a distance of about 0.6 m (internal) and 1.1 m (external) from the axis of the support.

As regards the results of the tests, some considerations must be stated beforehand: indeed, since the campaign of July was a sort of initial setting of a new (and enhanced) instrumentation, some malfunctioning lowered the value of the final results. In particular, an absolute sensor for the evaluation of the pressure broke just before the start.

The sensors worked well but, due to problems of initialisation and zeroing, the final figures are not always reliable. In the following some example of the results are given; for further details, please, see [ref. 7].

Fig. 1 to 4 show an example of the data logging related to a passage in parallel route; fig. 1 gives the overall arrangement of the working post; fig. 2 shows the position and speed of the ship during the test, fig. 2 contains the tracks of the velocity of the water (longitudinal and transversal components) measured by the self-made currentometers, fig. 4 gives the values of the wave height measured by a couple of capacitive probes. Of course, times on fig. 2 to 4 are synchronised.

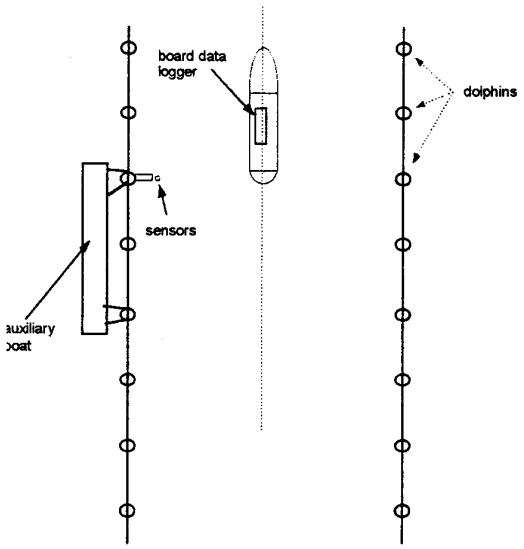

Figure 1- general layout of tests in parallel route

6. . WHAT THE TESTS SUGGESTED FOR THE IMPROVEMENT OF THE DATA LOGGING SYSTEM

Apart from the pressure sensors - that, unfortunately, showed some inconveniences and required a maintenance operation -, the main problem occurring in each part of the tests was the difficult zeroing of the sensors due to the impossibility of obtaining a condition of zero velocity of water and no change in the water level. Moreover, although the moving of water prevented from a correct zeroing, a procedure of zero for sensors was used both for velocity and wave height sensors. For velocity sensors, a tube was introduced

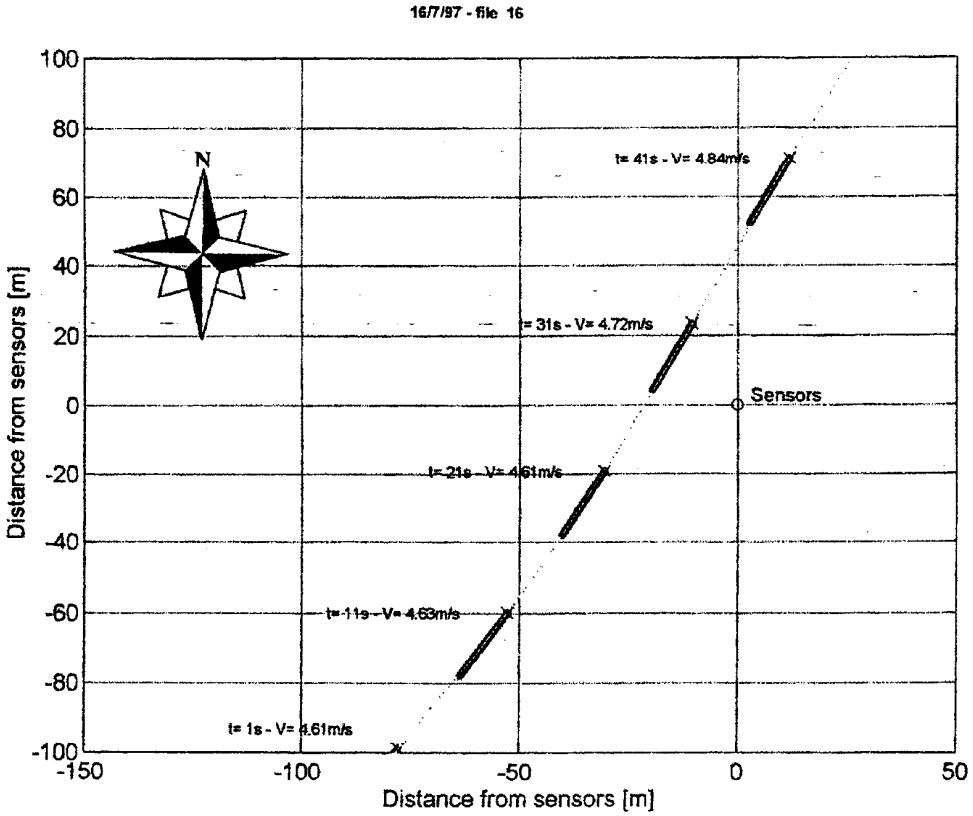

Figure 2-position and velocity of the M/B (test in parallel)

sensors was used both for velocity and wave height sensors. For velocity sensors, a tube was introduced in the cylinder keeping the rod and the sphere so avoiding the effect of the water velocity on the sphere and maintaining the sensor in position of zero.

For the capacitive probes a true calibration was made by keeping the probe in the water and reading directly the positions of zero and span (meanly, due to the waves). The zero position was read in a zone where the water was completely calm and while keeping the probe in the same position (and height) it had on the support. Spans were revealed by immersing and de-immersing the probe at its maximum position and reading the value given by the station of conditioning of the signal coming from the probe. These values (due to the linearity of the system) allow the determination of the scale of conversion from the voltage out from the station and the corresponding value of the height of the water.

In both cases, during calibrations an acquisition was performed in order to record the values of the voltage corresponding to each condition of zero for every sensor; nevertheless, the files containing the read values show the low efficiency of this system of revelation of the zero. The system used could not prevent the presence of fluctuation in velocity and height of water so a correct determination of the zeros and spans involved in each measurement was impossible.

For future campaigns, an improved laboratory method to determine the procedure of zero for the instruments should be set up which must be repeated in the zone where the measure has to be done.

In particular, for the velocity sensors, a system capable of blocking the group rod - sphere must be

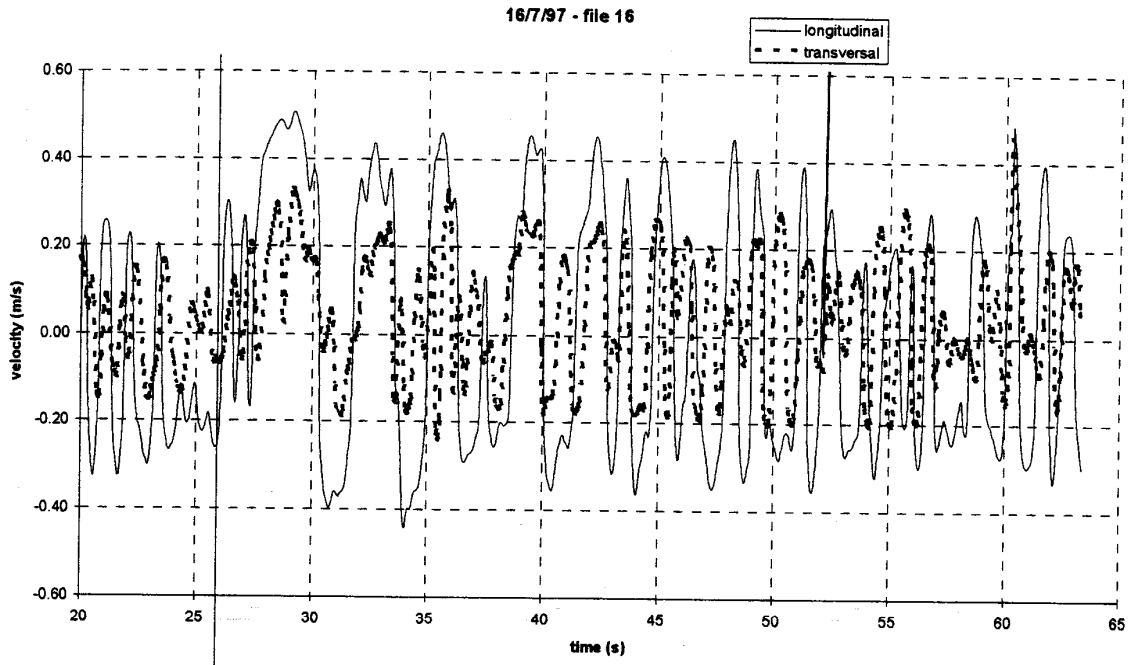

Figure 3 - water velocity (test in parallel route)

passage in direction N
(18 km/h)

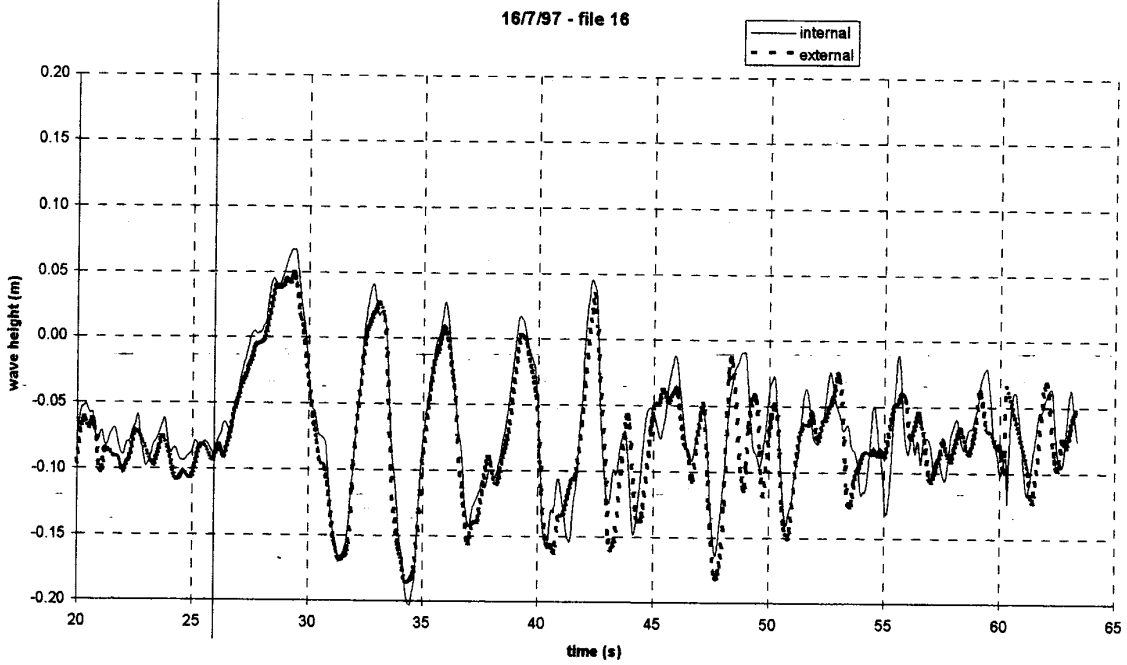

Figure 4 - wave height (test in parallel route)

set in order to allow the phase of zero before the tests. As regards the capacitive probes, the preliminary set must be obtained by creating a zone of calm water near the support and measuring the maximum and minimum immersion of the probes (span + and -) and the position corresponding to the level of undisturbed water (0).
Moreover, other serious problems came from the choice of the sites of tests and from the construction of the structures for the support of the sensors. Practically in each case the agreed conditions were not respected and the structures were not suitable for the use they were destined to; in the occasion of the final tests a preliminary inspection of the sites and a follow up of the setting of the chosen sites will be necessary.

Finally, due to the continuous variation of tide, a better revelation of the mean level of the water is required; this will be done by using an absolute pressure transducer capable of reading the level of the water with high precision. Such a transducer is already available in our Department but it could not be used because of the abovementioned malfunctioning

7. CONCLUSIONS

Finally, it is possible to say that the campaign of data logging carried out in July in the frame of LIUTO WP 4.2 gave important indications about the development of the very complex instrumentation necessary to perform the final comparative tests of environmental behaviour of both the present hull and the innovative one. Although a final word about the possibility of using the sensor nowadays built and tested is still to be said, the scene where tests will be made is substantially clearer so as the necessary improvement of the whole measurement system.

Of course, the future of the WP 4.2 of the LIUTO project will show the opportunity of organising another step of testing on the described system of measurement ; in any case , the information gathered in the occasion of this pre-testing activity will simplify the organisation of the final testing.

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