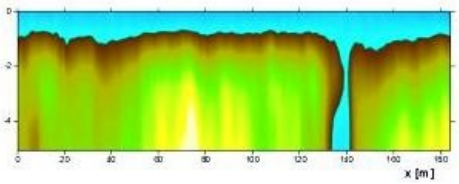
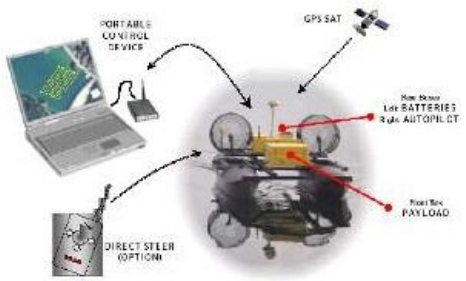
AUTONOMOUS UNMANNED SURFACE VESSEL

Green Air Pushes





Bathymetry is largely used for measuring ocean and sea depth but there are also many other different applications in lakes, dams, rivers and fresh water basins. Logistic constraints as well as risks and economic issues make bathymetric measurement, especially in fresh water, not a simple task. This, in fact, normally implies the use of a motorised craft of a certain dimension, capable of accommodating the helmsman and at least one operator of the measuring system plus the relevant equipment. Often boats have to be transported to difficult to reach places or have to operate in sites hazardous for humans such as quarry lakes, landslides or contaminated areas. At times they are lonely places, in mountainous or very isolated areas, sometimes not particularly accessible by car and occasionally difficult to reach even on foot. For these and other reasons, including economic reasons, robotic survey platforms are proving a good alternative to manned vessels. Initially developed for military applications, they are now becoming economically effective and relatively popular also in the civil market. Most unmanned survey platforms are water propelled but the Italian company aerRobotix has adopted air fans for their â€˜CatOneâ€™, a new autonomous Unmanned Surface Vessel for hydrographical measurement and environmental monitoring.

CatOne is a family of multi-purpose vessel robots especially effective in situations that require recurring, very repetitive, long endurance activities or in dangerous environments and sensitive ecosystems, particularly in fresh water basins. In this respect, several characteristics play a significant role, namely: very low draft, absence of propeller and rudders in the water, zero pollution emission (thanks to its electric propulsion), low noise, no disturbance to the depth contour of shallow water and to the flora and fauna.

The CatOne configuration is based on the catamaran concept because of its favourable characteristics of roll stability. Propulsion is provided by two aerial propellers, each driven by a regulated electric engine. Symmetric management of the engines push exploits velocity control, including reverse motion; differential modulation provides directional stability and control. No rudders, hinges, fins or other devices are needed. The only moving items are the engine’s ball bearings, shafts and aerial propellers. The absence of propellers and rudders in the water strongly reduces the risk of entrapment by floating objects and, in addition to its almost-flat bottom hulls, allows the vessel to operate also in very shallow water. All this of course contributes to providing the system with a high level of reliability, a very important feature necessary to guarantee uninterrupted long endurance mission capability. Power is provided by rechargeable Lithium-Polymer batteries, which allow up to 8 hours continuous operation on a single charge and quick recharging compatible with the logistics of a typical survey campaign.

Efficient Management

Low weight and small dimensions makes CatOne’s ground handling easy, typically managed in a few minutes by a single person. Partially disassembled it can be easily transported on the roof of a medium-sized car or inside a station wagon.The vessels are capable of conducting navigation fully autonomously along pre-programmed trajectories, slaved to GPS signal. The operator prepares the arbitrary scanning routes as a sequence of waypoints from the comfort of an office environment, based on available cartography and mission requirements, through a user-friendly interface. Then he/she deploys the system (10 minutes), uploads the mission instructions through a wireless link and initialises it, together with the measurement device (payload). The complete mission is then autonomously executed by the robot. Virtually no interaction is required during the mission. Nevertheless, a Portable Control Device (PCD) allows a useful dialogue

with the vessel through a bi-direction data link. One can modify the pre-programmed paths even during execution and monitor the state of the system and the progress of the survey. In the presence of other surface traffic (boats, ships) or any other circumstances not known beforehand in lakes /lagoons, the flexibility offered by the PCD is very valuable.

As an option, the operator can directly steer the vessel by a dedicated radio-control, bypassing the automatic system and taking full authority. This is useful, for instance, to trace the borders of a basin or to navigate in any other circumstances where assigning a reference trajectory is impossible or not practical.

The control system assures autonomy and operational flexibility. It consists of:

- a computerised onboard system. It autonomously drives the mission taking GPS data as a positioning reference, integrated by inputs from inertial and magnetic sensors. By comparing the vessel's current position and state with the uploaded reference values, the system controls velocity, attitude and stability by regulating the engine's turn rate.
- a Portable Control Device (PCD), equipped with a modem. It allows mission planning, rehearsal, health and mission monitoring, online re-planning, data download and first level analysis. The PCD is Windows based, and the interface with the operator is based on moving maps, drag-and-drop waypoints, soft-buttons for mission activation, upload etc. This device also includes a 'grid auto-planning' capability that allows the operator to automatically create the navigation scanning grids.

The optimal cruise speed of CatOne is around 5-6km/h. This guarantees the most efficient power management for long endurance. On the other hand, such speed is suitable for the correct performance of a number of sensors. For this reason, in the case of very large basins, it can be profitable to operate more units at once. The control system allows a single operator to monitor up to three of them, the paths of which are properly optimised through the aforementioned grid auto-planning capability.

Bathymetry is the first application of CatOne. If local GPS signals are good enough, depth data are measured by the echo sounder and linked to the onboard GPS rover station readings which are taken automatically at fixed predefined linear steps (e.g. every 2 metres). The GPS system is configured in order to receive the differential corrections transmitted by the reference station on ground, previously geo-referenced. Based on the first year of activity the use of the USV CatOne for bathymetry has proven effective. The suitability of this configuration has been carefully assessed and optimised, in particular, for use in fresh water and small to medium sized basins. The fact that a single operator can manage the entire process has positively influenced its cost effectiveness. For these reasons, aerRobotix has now undertaken a fully operational routine in this respect.

Multi-purpose Capabilities

aerRobotix are also aiming to increase the bathymetric mapping productivity by also considering the installation on board of multi-beam echo sounders and side-scan sonar. In addition to the typical equipment for bathymetry, the robot can host and carry on board a large variety of payloads (e.g. water sampling devices etc.). Therefore, other areas of applications are being considered, tested and developed, ranging from hydro-geology to environment monitoring. An interesting application is presently the subject of joint research being carried out by the DIATI (Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture) of Politecnico di Torino and the Dipartimento di Scienze della Terra of the Università di Torino (Italy) with a contribution by aerRobotix: the high percentage of water loss because of seepages in irrigation and hydroelectric plant canals is a very sensitive problem on a global scale. The idea under evaluation involves the identification of water losses by detecting anomalies in the electric resistivity distribution along the canal by means of waterborne CVES (Continuous Vertical Electric Soundings). Such measurements have been experimentally carried out with CatOne towing a specialised electrode array. The collected results pointed out a very clearly evident anomaly corresponding to actual leakage present in a canal segment. A strong resistivity decrease is pointed out by soundings, linked with a highly vegetated zone at the corresponding end of the concrete sides of the canal.

Results achieved so far have demonstrated the potential of this method and justify the research presently being carried out by the team.

The reasonably large volume and weight available for the service payload allows, among other, for the easy installation of Acoustic Doppler Current Profilers (ADCP) for mapping the water flow intensity across river and canal sections. Such measurements are normally carried out by operators on the ground (e.g. on footpaths or bridges) or on boats. The advantage of being able to automatically perform the measurements everywhere and the possibility of doing away with manned boats are quite obvious. The environmentally friendly characteristics of CatOne make it suitable for ecologically sensitive and protected areas and applications can be envisaged also in this frame. The relatively large payload capability allows for the integration of devices specialised in collecting water samples and the integration of a winch capable of lowering the measuring probes at different depth is being developed.

Further Reading

- C. Comina, C. and Sambuelli, L. : "Agricultural canals seepage detection: first evidences of the effectiveness of Continuous Vertical Electrical Soundings". 30th National GNGTS, Trieste(Italy) Nov.14-17, 2011).
- A. Romano and P.Duranti: "Autonomous Unmanned Surface Vessels for Hydrographical Measurement and Environmental Monitoring", FIG Working Week 2012, Rome (Italy) May 6-10,2012