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EXPERIMENTALLY-DETERMINED MANOEUVRING CHARACTERISTICS OF THE "C-SCOUT" AUV AND COMPARISON WITH RESULTS FROM SIMULATIONS

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In September of 1998, we initiated a collaborative effort between the Institute for Marine Dynamics (IMD) of the National Research Council of Canada, and the Ocean Engineering Research Centre of Memorial University of Newfoundland, to design a streamlined autonomous underwater vehicle (AUV) which would serve as a test-bed for IMD and graduate-level research. This AUV, called "C-SCOUT", is intended to serve as an experimental platform for the development of control and propulsion systems, the testing of vehicle components, and as a general research and development tool for autonomous engineering systems. Future versions of this AUV, due to the modular design, could be configured for a wide variety of missions, including search and survey, under ice operations, iceberg profiling, oceanographic sampling, environmental effects monitoring, and mine detection and countermeasures.

This paper describes the preliminary hydrodynamic testing phase of the AUV, which took place in the Ocean Engineering Basin and Towing Tank at IMD. Manoeuvres included speed tests in both forward and reverse directions, turning circles, zigzag and figure-of-eight manoeuvres. Other information useful to the underwater vehicle community was determined, including vehicle endurance and electrical loads during the various manoeuvres.

The position and orientation of the submerged vehicle was measured using a QUALYSIS™ optical tracking system; this uses of a set of reflective spheres which are automatically tracked by a series of video cameras - the spheres are mounted on top of a slender surface-piercing mast which is attached to the top of the vehicle near its yaw centre. This system limits the vehicle to manoeuvres in a horizontal plane about one metre below the water surface. The effect of the mast lead to results that were not representative of the performance of the vehicle alone, however, the precision with which the system could measure the vehicle track and the ease with which it could be set up and used, made for a worthwhile tradeoff.

Concurrent with the design and construction of this AUV has been the development of a numerical hydrodynamic simulation of the vehicle, which was formulated using MATLAB™ and SIMULINK™. This simulation will be used for predicting the motion paths and performance of the vehicle for mission planning and post-mission analysis. Results from the in-water experiments with the full-scale vehicle provided a validation for the numerical simulations and an overall feel for the vehicle's performance characteristics.

To make the vehicle simple to reconfigure, it has been constructed using modular sections; see Figure 1. Each module is fabricated using circular endplates, flat-bar longitudinal stringers and a sheet-metal skin, except the nose and tail which are made from fibreglass. All modules are free-flooding except the central pressure vessel that contains the computer and control electronics. A particular sensor package can thus be housed in its own module, which can be quickly bolted into place.

The construction and testing is to be accomplished in stages; the baseline configuration uses four control surfaces aft and single aft propulsor. The length of this configuration is 2.3 m with a hull diameter of 40 cm and an overall height of 106 cm from fin-tip to fin-tip. By simply unbolting and rotating the fin module 45º, the vehicle can be tested with the four fins in a '+' or 'x' orientation; with another module three fins can tested in a 'Y' or 'inverted-Y' orientation. Thus the modular construction approach permits us to establish the manoeuvring characteristics for multiple vehicle configurations, easily. The placement of the six through-body thrusters provides control in heave, pitch, sway, yaw and roll; this makes the vehicle highly manoeuvrable even at low forward speeds, and thus able to hover in a cross-current. Although common practice is to use passive roll-stabilization (by deliberately separating the centres of gravity and buoyancy), the fully-actuated version will permit any orientation during hovering or even while inverted, which will permit a single sonar to point downwards (for bottom mapping), sideways (for iceberg profiling) and upwards (for under-ice profiling).

A full-sized replica of "C-SCOUT" has been constructed for use with a Planar Motion Mechanism (PMM). This permits a comparison of hydrodynamic coefficients that are obtained from forced-motion manoeuvres and the self-propelled vehicle.

The results to be presented in this paper will be for the baseline configuration only.

Figure 1. "C-SCOUT" in the fully-configured condition with 8 control fins and 6 tunnel thrusters