DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING
Department of Mechanical Engineering

Team 26

Hydrodynamics and Control of a Towfish for Autonomous Underwater Vehicle Docking

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International Submarine Engineering Ltd.

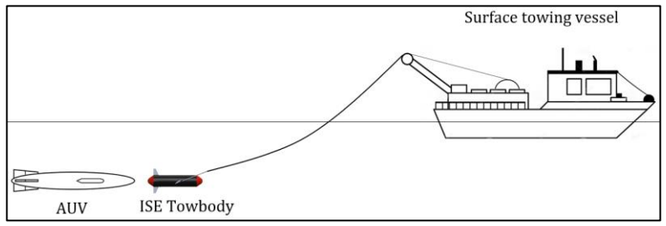
Project Description

International Submarine Engineering Ltd. (ISE)

Our client ISE specializes in the design and integration of autonomous and remotely operated robotic vehicles.

Project Scope

Develop a towbody prototype with a control system capable of autonomously maintaining the stability of the towed body using two independently actuated wings.



The prototype towbody is to act as a proof of concept for a towed AUV docking station intended for autonomous recharging of AUV batteries. This capability would remove the need for AUV recovery, significantly improving deployment longevity and user safety.

Requirements

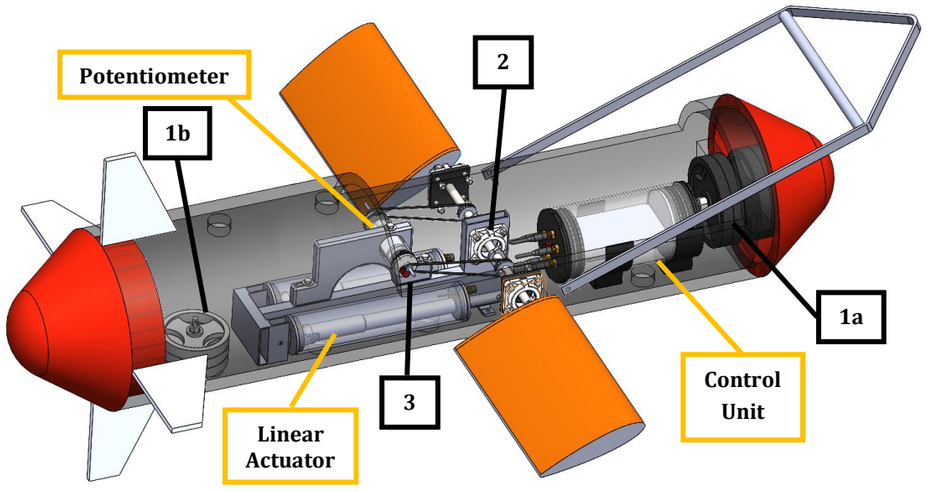
- The towbody should be 1lb±1lb positively buoyant
- Wing angle feedback belts tensioned so that they transmit torque to potentiometer shafts without slipping
- On-board control system must be capable of autonomously stabilizing the towbody roll angle and depth at simulated wave heights of up to 1.25 m
- Towbody must be capable of operating at and maintaining depth at speeds between 2 and 3 knots with an error of 5%.
- The deflection angle of the control surfaces must not exceed 20° during testing
- Implement external power cycling capability

Design Process

- Develop equations of motion for towbody roll and heave for creation of a hydrodynamic system model, and determination of approximate control gains.
- Implement mechanical modifications to existing prototype to improve towbody performance.
- Develop method for topside communication between user and towbody for adjusting control inputs and gains.
- Write an Arduino control algorithm for autonomous control of towbody state.
- Test towbody in Dalhousie Aquatron to fine tune control gains for optimized performance.

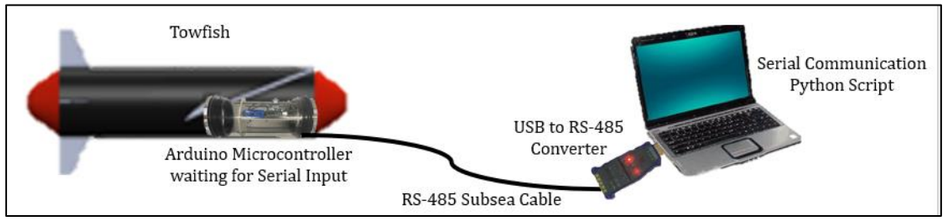
Detailed Design

Mechanical



1a – Bow Trim Weight Assembly	1b – Stern Trim Weight Assembly	2 – Corrosion Resistant Acetal Bearings	3 – Improved Wing Shaft Feedback Torque Transmission
			

Electrical



Serial Control Communication Sequence

1. User inputs a command when prompted by Python script on topside PC.
2. Python script encodes user input to Unicode data format for serial transmission.
3. Topside PC transmits serial data through USB port to RS485, through subsea cable, to RS232 at Arduino microcontroller.
4. Arduino receives, decodes, and parses the data.
5. Parsed command data is interpreted, and appropriate control action is taken by the Arduino.

Design Features

Mechanical

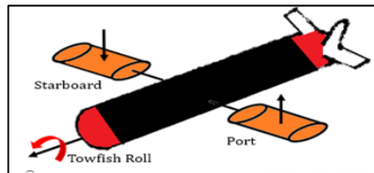
- **Potentiometer Mount**: Bolt holes slotted to increase distance between wing shafts and potentiometer shafts to increase tension and improve torque transmission.
- **Corrosion Resistant Components**: Corroded bearings and fasteners replaced with corrosion-resistant alternatives.
- **Trim Weight Mounts**: Threaded rod and bolt added to bow and stern of towbody to allow for quick adjustment of trim weight.
- **Wing Shafts:** adjusted to obtain a ±20° angle of attack.

Electrical

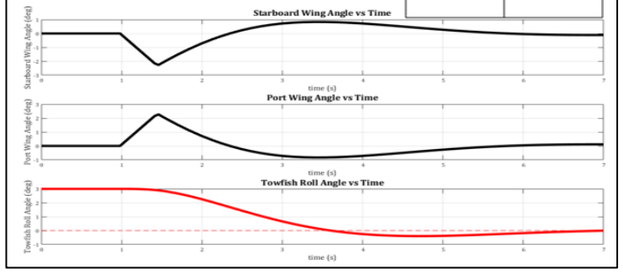
- **Simulink control simulation:** Simulated system dynamics to estimate required PID control gains.
- **Arduino control code:** Full wing calibration and control system code written and uploaded to Arduino microcontroller.
- **Serial communication:** Method to send and receive serial data between topside computer and towbody while submerged.

Simulation Results

Ex: Driving Towfish to Neutral Position from 3° Portside Rotation



Parameter	Value
Max Overshoot	13%
t_{PEAK}	4.8s
t_{SETTLE}	6.1s



Project Status

- **March 25:**
  All mechanical upgrades installed onto the prototype.
  Control system code debugged and uploaded to Arduino.
- **March 27:**
  Control system simulation refined to test control gains.
- **March 28 – April 1:**
  In-water control system testing at Dalhousie Aquatron.