Olin Robotics Collaborative Autonomous Submersibles (ORCAS) SAG Final Report

Overview

With the $3000 we received from the SAG Grant, we finalized, designed, and prototyped our vehicle and subsystems on schedule. Because of this, we were able to focus on more of our goals for the 2017-2018 year, especially the ones below.

2017-2018 Goals

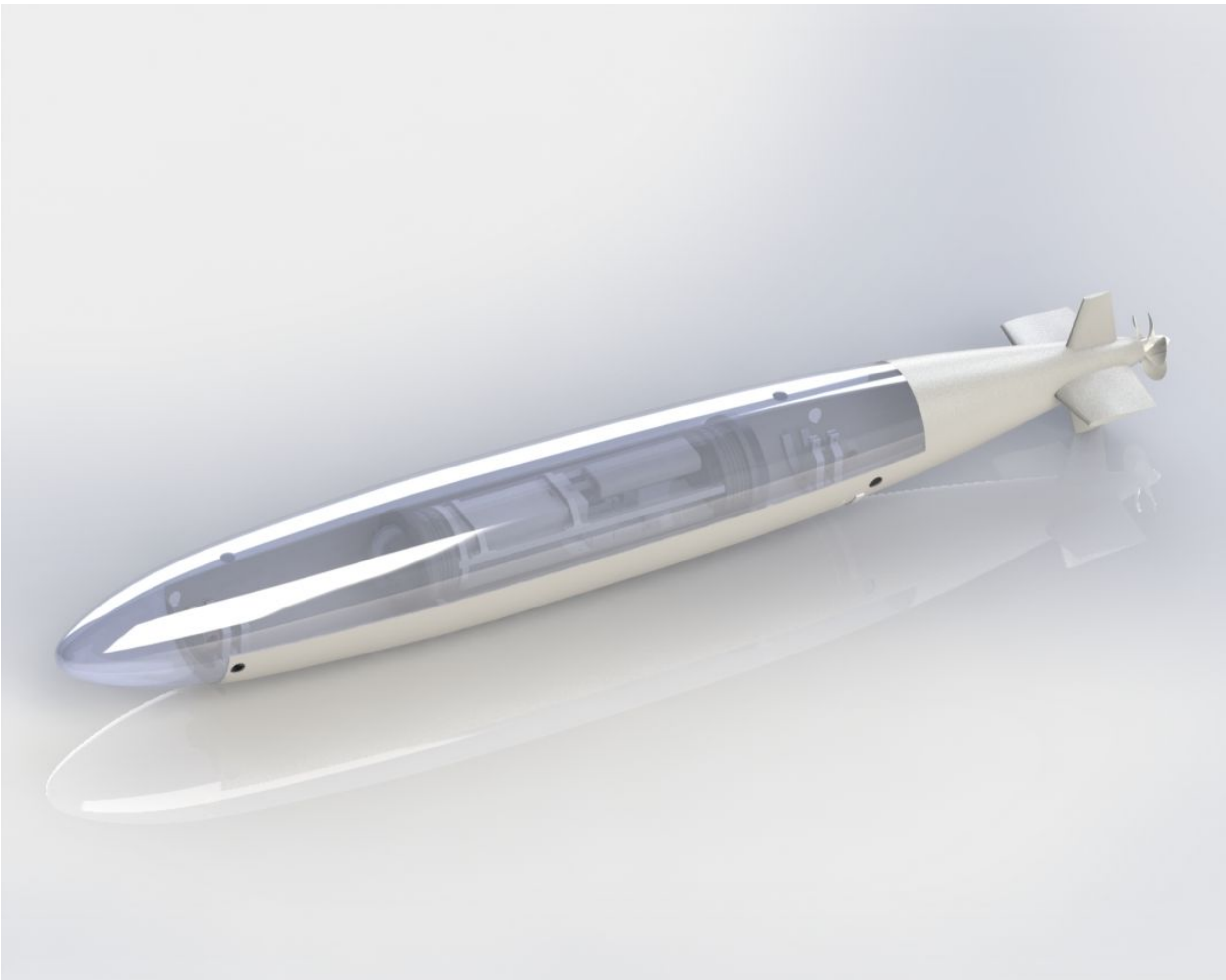
- Improve knowledge transfer to first years
- Develop a foundational aquatic robotic vehicle platform
- Develop structured light laser imaging sensor system
- Develop cross tunnel thrusters for lateral and axial movement

Knowledge Transfer

This year, ORCAS onboarded five new members from the class of 2021 and developed a leadership structure consisting primarily of sophomores. As a result, this year served primarily to develop opportunities for sophomores to expand on their leadership skills and first years to learn from and interact with experienced engineers. To do this, we put a lot of consideration into teaming. Splitting electrical, mechanical, and software tasks out into subteams headed by sophomores allowed them to serve as mediators between senior engineers and new members. When assigning teams, we made sure to have one senior engineer on each subteam to impart their knowledge and serve as advisors for the subteam leaders.

Developing a vehicle platform

We spent a good amount of time this semester developing the supportive mechanical systems for an intermediate testing rig called the Skipjack. Originally a 40 inch model submarine, this vehicle will serve as the first testing platform for the Olin Cross Tunnel Thruster system. Because the submarine was originally a model, there was no pre-existing CAD to describe its geometry. As such, a lot of effort was put into accurately modeling the complex 3D geometry of the submarine's hull. The CAD model was essential for further designing other mechanical components of the sub, such as the dedicated laser/camera pressure hull at the fore of the vehicle, as well as the placements/mounting points for the cross tunnel thrusters. This work in modeling the future testing platform for this project will expedite the development process in the coming semester as the structured light navigation gets integrated directly into the main vehicle. In addition to using the CAD as a tool for designing mounts that can interface with the sub's fiberglass hull, we will be able to use the CAD model to determine important and complex features of the submarine, such as the center of buoyancy and center of mass, as to make more informed and nuanced engineering decisions.



Develop Structured Light Laser Imaging Sensors

A high priority this semester was the development of a structured light laser imaging sensor system. Developing a highly maneuverable UUV for navigating littoral (shallow, coastal) waters requires the ability to avoid obstacles (i.e. underwater pylons, submerged bridge columns, etc.) while navigating. As such, a large amount of research and development effort went into creating a successful vehicle-mounted structured light laser imaging system.

Develop Cross Tunnel Thrusters for Lateral and Axial Movement

http://www.instructables.com/id/How-to-Use-Water-Flow-Sensor-Arduino-Tutorial/

A third focus involved conducting research and testing the design and application of cross-tunnel thrusters. This form of thruster reduces drag by internally packaging the motor and tunnel system. It is used for low-speed precision navigation in submarine systems, especially for resisting surface-level wave thrust or docking maneuvers. We replicated the cross-tunnel design in CAD so that variations on tunnel length, wall thickness, and overall design could be rapidly prototyped. This included maximizing tunnel inner diameter while retaining material stability, testing fit tolerances for hardware-free attachment, experimenting with detachable tunnel connections, and creating a mounting stand that would match the geometry of the Skipjack hull. Additionally, we prototyped a solution for sealing existing motors with electrical tape and epoxy so that we could submerge the thrusters and determine flow rate. We are planning to continue this work with larger, water-proof thrusters, and scale these initial designs to integrate cross-tunnel thrusters into other submarine platforms.

Reflection Piece

Isaac Vandor (on behalf of ORCAS)

While my time in the robotics lab has been incredibly interesting and pushed my own academic pursuits further, all of the projects I've worked on have been single-purpose developments meant to complete a task. In many cases, these projects were abandoned and/or taken apart immediately afterwards. This year, I wanted to try something a little different and build a research cohort focused on the development of an entirely new class of unmanned undersea vehicle, from the ground up.

With that goal in mind, I organized a group of students into subteams and together we made progress on the technology development necessary for such a vehicle. Through that process, I've learned a lot about the principles of underwater vehicle development, sensor and thruster design, and technology integration. I've also learned an incredible amount simply by managing and leading a group of engineers at varying knowledge/experience levels through a research project. Arguably, the greatest benefit the SAG grant provided me this semester was the opportunity to spearhead a project entirely on my own, with responsibility for coordinating schedules, design and fabrication timelines, and budget constraints among all of the other responsibilities that come from being a project manager.

One of the most interesting facets of the project that came about as a direct result of the SAG grant was the ability to develop a multi-semester project with the knowledge that parts would be available. By removing the barrier to funding each semester separately, the SAG grant allowed us to dive deeper into each of the technical subsystem challenges required before building out the vehicle as a whole. Specifically, I focused my efforts on developing a structured light laser imaging sensor system and computing stack that would enable the vehicle to identify and safely avoid submerged obstacles. Developing such a system required a lot of technology development related to sensing systems and computer vision that has already found its way into multiple other projects this semester. In later iterations of the Skipjack platform, this output will be directly integrated into the vehicle navigation algorithms themselves. By providing us with the ability to test multiple iterations of this system and focus on developing technology from the ground up, the SAG grant ultimately enables us to build a more robust full system in the future.