AUVSI RoboSub

Team #04 RoboSub

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ABSTRACT

This report contains the needs, proposed solutions, and other defining elements of the 2015-2016 RoboSub senior design project. The goal of the team is to create an autonomous submarine meeting the requirements to compete in the AUVSI 2015 RoboSub competition. All the information in this report specifies what is needed and the steps and solutions that will best accomplish that. The project is a continuation of earlier senior design projects, which were still in development and incapable of meeting the competitions requirements. The needs of the submarine are to install and utilize the proper devices for full functionality. The components of the sub have been explored, and groups have been created with specific tasks to move the project forward. A plan has been implemented and goals have been set to complete this project more efficiently.

ACKNOWLEDGMENTS

On behalf of the AUVSI Robosub team, thank you to each and every individual who have or will contribute to the team's effort to competing in the AUVSI Foundation Competition. To be more specific, thank you to the College of Engineering for sponsoring the group. Thank you to Dr. Victor DeBrunner for working closely with one of the team members to improve the image processing. Thank you to Dr. Bruce Harvey and Dr. Jonathan Clark for being advisors and overseeing the members on the team as tasks are being completed. Without all of the extra support, much of this project would not be completed. Being able to implement the knowledge gained from courses taken at the College of Engineering, only proves that the college is willing to invest in the students to create a better future for the students.

With that being said, the AUVSI Robosub team appreciates your help.

1 Introduction

With a substantial increase in the use of autonomous systems, a growing need for developing this technology has led to the formation of many projects and competitions designed to spur research into this area. From research to military operations, autonomous systems can grant access to areas previously inaccessible to humans. Many competitions currently encourage people to develop autonomous systems of their own. One such competition is the AUSVI RoboSub competition. The objective of this project is to design an autonomous submarine capable of competing in the AUSVI RoboSub competition.

Currently, the RoboSub we have is not able to meet performance specifications set down by the rules of the competition. The sub must complete a number of tasks on a course as shown in Figure 1. This paper describes the problems of the current design, the goal of the future design, and steps needed to in order to accomplish the specified goals. Ultimately, the team hopes to make the current RoboSub able to compete in the competition next year.

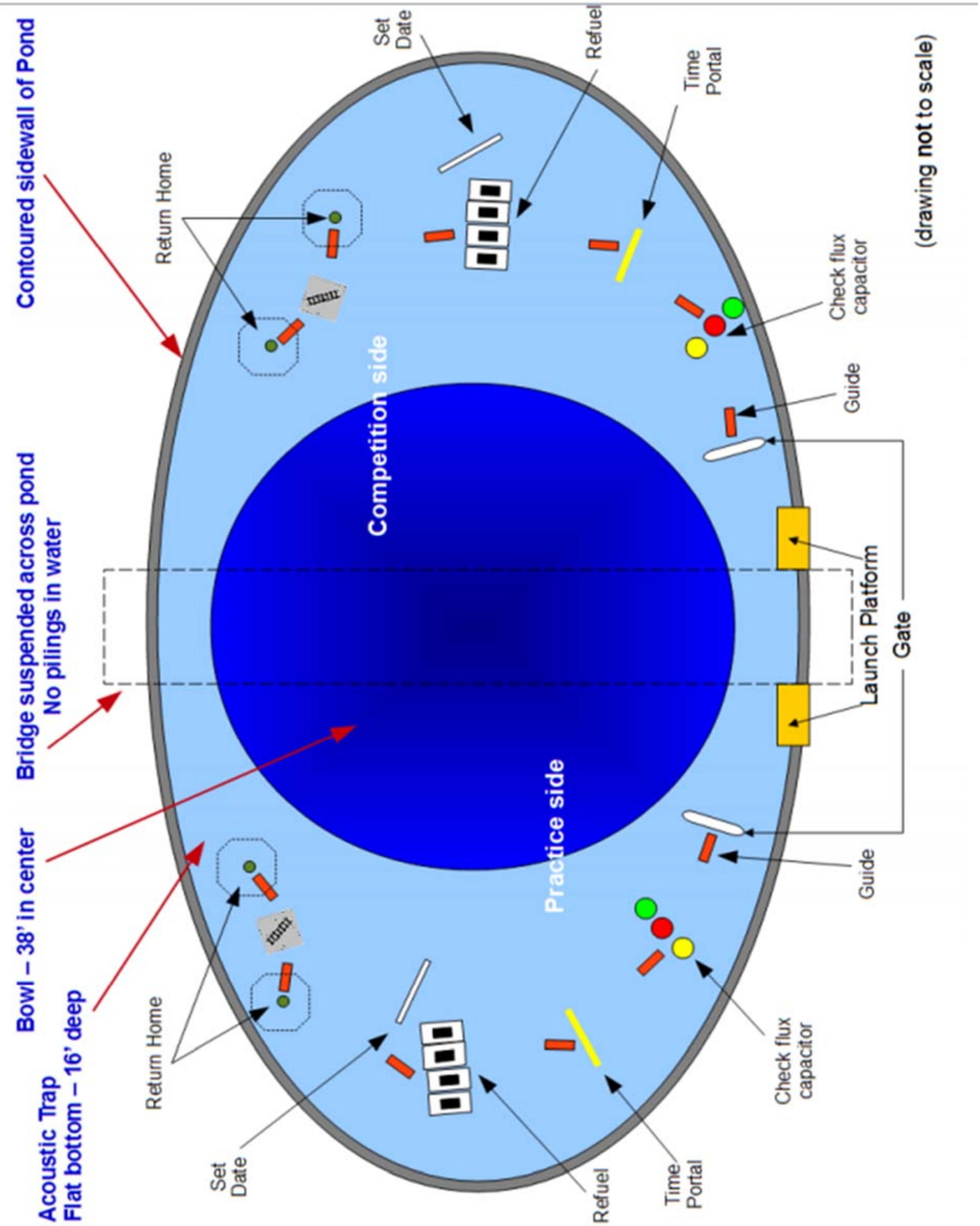

Figure 1. Schematic of competition pool

2 Background

There have been many autonomous submarines built in recent years. The first robotic submarine used by the U.S. was the Autonomous Benthic Explorer developed in the mid 1990's.[2] The RoboSub used in this project is a continuation of multiple years of work by senior design groups, and is modeled after the same type of subs used by many other teams competing in the AUSVI RoboSub competition. In recent years, there have been many similar projects focused on developing autonomous submarines for various applications such as research, military operations, and exploration. Our sub differs from these projects in that it is focused on a specific set of tasks described by the rules of the AUSVI RoboSub competition, such as swimming through certain gates, maintaining depth and heading along a certain path, and firing torpedoes at markers. To help start the project off, there are many articles and other related literature describing autonomous subs and their design. One such article is "The NPS AUVII Autonomous Underwater Vehicle Testbed: Design and Experimental Verification" published by the American Society of Naval Engineers in 2009.[3] The previous Senior Design team also wrote a manual on the specifications and operation of the existing RoboSub.[4] This will be the main source of information used in developing this year's project.

The previous RoboSub teams that have worked on this project have made some progress. They were able to make a sealed hull with a cubic design, mount six thrusters for forward, backward, upward, downward, and rotational movement. The previous teams were also able to design movement code to maintain a somewhat consistent navigation path underwater, as well as some visual code that could identify an orange obstacle and its orientation. At the start of the year, the sub had all the necessary components to navigate underwater and maintain its depth and heading relatively consistently, an air actuation system that could be used for task completion, and preliminary models for torpedos, marker droppers, and gripper mechanisms.

3 Problem Statement and Project Scope

- The RoboSub must comply with all of the AUVSI foundation’s competition rules:
    - Sub must be less than or 125 lbs
        - Sub must be less than or 84 lbs for no penalty to be incurred.
    - Sub must be maneuverable through “gates”
    - The torpedoes size, weight, markings and potential “loss” are identical to the Markers.
        - The torpedoes must travel at a “safe” speed.
            - A “safe” speed is one that would not cause a bruise when it strikes a person
    - Each marker must fit within a box 2.0” square and 6” long.
        - Each must weigh no more than 2.0 lbs in air.
        - Each marker must bear the team name or an emblem.
        - Penalties are as follows:
            - § Any marker that exceeds these limits by less then 10% will result in a 500-point penalty. Any marker that exceeds these limits by more than 10% will be disqualified.
- The total cost must not exceed the allotted budget
- An example of competition constraints is listed in Table 1.[1]

Subjective Measures	**Maximum points**
Utility of team website	50
Technical merit (from journal paper)	50
Written style (from journal paper)	50
Technical accomplishments (from static judging)	75
Craftsmanship (from static judging)	75
Team uniform (from static judging)	10
Team Video	50
Discretionary static points (awarded after static judging)	40
Total	400
Performance Measures	**Maximum points**
Weight	See Table 1
Marker/Torpedo exceeding weight or dimensional specifications by < 10%	-500 per marker
Pass through the validation gate	100
Maintain a fixed heading through gate	150
Follow the "Path"	100 /segment
Check Flux Cap (any solid, Red than Green)	400, 800
Time Portal (>½ above, <½ below & parallel) Straight through // with Style	400, 600 // 1000, 1400
Refuel: remove lid	700
Refuel: any, primary/secondary	500, 1200 / marker
Set Date: remove lid	700
Set Date: any, corr lg, corr sm	500,1000,1500 / torpedo
Surface within an Octagon	500
Surface within the correct Octagon	2000
Surface with the Object	600 / object
Drop the Object	200 / object
Object on Railroad	1000 / object
DeLorean in front of Train on Railroad Track	1000
Finish the mission with T minutes (whole + fractional)	T x 100

Table 1. Competition Scoring

4 Objectives

The objectives of this project will follow closely to the competition guidelines set down by the AUVSI RoboSub Competition. The ECE RoboSub team is collaborating with the ME RoboSub team, and both will be working on the same sub. The main objective of the team is to make the RoboSub capable of meeting the competition requirements. As such, the team would like to have systems to perform each of the required tasks that work at least to some competitive degree by the end of the spring semester. Both the ME and the ECE RoboSub teams will split the different subsystems of the project up, so that each team can effectively focus on tasks within their area of expertise, and the larger goal of making the sub competition ready can be achieved. Since the two teams will be working on the same sub, some of the tasks may overlap between members of the respective teams. While members of each team may be working on the same task, the teams will remain separate and will simply combine resources to design each of the subsystems. The objectives for this semester will focus on building models for each of the subsystems required and get mounting them to the sub, so that the next semester can be spent refining and debugging the systems.

5 Methodology

The team plans to operate as closely as possible to a prescribed schedule of events. Due to the nature of the project, and the fact that the official rules for the competition do not come out until later in the year, this schedule is subject to change as the team progresses and new constraints appear. The ECE RoboSub team will be collaborating with the ME RoboSub team and working on the same sub by breaking up the subsystems and working on individual parts of the sub to complete a whole working unit. As such, the members of each team will be working closely on different parts of the subsystems, and the schedules of both teams will overlap based on which part each of the sub the team members are working on at any given time. Tentatively, the team plans to familiarize itself with the operating systems of the sub, and have an operable sub that can properly maintain its swim path and move consistently underwater by the end of October. This task will be assigned to the all ME and CE members. By the end of November, the team plans to have designs for a new hull and have a sub that is able to identify each of the different task zones and determine which operations to carry out. The hull will be designed by the ME members, while the coding for task recognition and operations will be designed by the CE members. By the end of December, the team plans to have a gripper, torpedo launchers, and beacon recognition components designed, built, and mounted on the sub. Gripper and torpedo launcher design will be carried out by the ME members, while beacon recognition and operating code will be designed by the CE members.

5.1 Scheduling

	Task Name	Duration	Start	Finish
1	**Troubleshoot Subsystems**	**26 days**	**Mon 10/12/15**	**Fri 11/13/15**
2	**Image processing**	**5.2 wks**	**Mon 10/12/15**	**Fri 11/13/15**
3	Orientation ID	1 wk	Mon 10/12/15	Fri 10/16/15
4	Shape ID	2 wks	Mon 10/19/15	Thu 10/29/15
5	Color ID	1 wk	Fri 10/30/15	Thu 11/5/15
6	Debugging	1 wk	Fri 11/6/15	Thu 11/12/15
7	**Hull**	**5.2 wks**	**Mon 10/12/15**	**Fri 11/13/15**
8	CAD current sub	3 days	Mon 10/12/15	Wed 10/14/15
9	Math/Testing	1 wk	Thu 10/15/15	Wed 10/21/15
10	Initial designs	8 days	Mon 10/12/15	Wed 10/21/15
11	CAD design choice	1 wk	Thu 10/22/15	Tue 10/27/15
12	Materials/Order parts	3 days	Wed 10/28/15	Fri 10/30/15
13	Procurement	1 wk	Mon 11/2/15	Fri 11/6/15
14	Assembly	5 days	Mon 11/9/15	Fri 11/13/15
15	**Navigation**	**5.2 wks**	**Mon 10/12/15**	**Fri 11/13/15**
16	Debug thrusters	2.6 wks	Mon 10/12/15	Tue 10/27/15
17	IMU control	1 wk	Wed 10/28/15	Tue 11/3/15
18	Depth sensor	1 wk	Wed 11/4/15	Tue 11/10/15
19	Navigation - Debug	0.6 wks	Wed 11/11/15	Fri 11/13/15
20	Submerge the AUV	3 days	Sat 11/14/15	Mon 11/16/15
21	**Redesign Subsystems**	**39 days**	**Mon 10/12/15**	**Mon 11/30/15**
22	**Gripper/Torpedoes**	**39 days**	**Mon 10/12/15**	**Mon 11/30/15**
23	CAD new/old designs	17 days	Mon 10/12/15	Sat 10/31/15
24	Claw-order parts	7 days	Mon 11/2/15	Tue 11/10/15
25	Claw-Assembly	8 days	Wed 11/11/15	Wed 11/18/15
26	Claw-Attach and Integrate	8 days	Thu 11/19/15	Mon 11/30/15
27	Re-Submerge	3 days	Tue 12/1/15	Thu 12/3/15
28	Debug Errors	5 days	Fri 12/4/15	Wed 12/9/15
29	Final Submersion	3 days	Thu 12/10/15	Mon 12/14/15

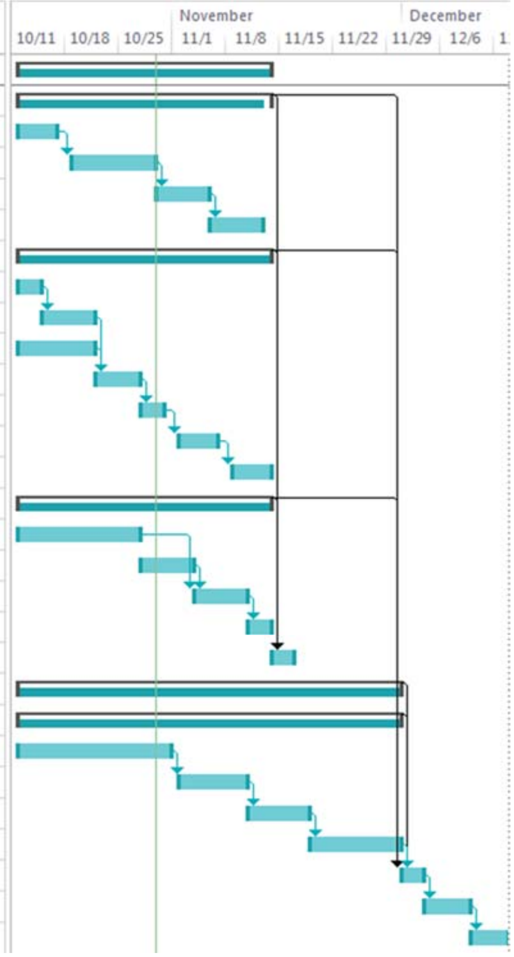

Figure 2: Gantt Chart

5.2 Resource Allocation

With the collaboration of the two RoboSub teams, tasks will be broken down into those pertaining to Mechanical aspects and those pertaining to computer aspects. Designing a new hull, calculating heat dissipation, designing a gripper, torpedo launcher, and frame mounts will be designated to the ME members. Designing the movement codes, task recognition, gripper movement, torpedo firing, and visual capabilities will be designated to the CE members.

The priority of the project is to run and perfect the initial sub left from previous years. Travis will continue implementing video processing into the code. By the end of the semester, code should be able to completely recognize all the possible obstacles, their location/orientation, and their color. This information will be sent to the navigation module. Gabriel and LaNeicia will continue to work on that. The data from the camera will be used to decipher the requirements of the obstacle, and propel the sub to carry out the specific task. Brandon will be finalizing the mechanical aspects relating to the torpedo. A marker dropper system will also be be implemented by the end of the semester. The member of the mechanical team will continue to work on a refined hull. The current design will be trimmed in a way that reduces the weight and buoyancy of the hull. It will still be able to hold the internal and external electrical components while keeping them cool and allowing for easy access to the internal parts.

6 Results

The navigation of the hull has for the most part remained intact. After running the thrusters individually, a problem was detected with one of the thrusters and one of the microcontrollers. When using the code implemented by earlier groups, after compilation, it returns a segmentation fault.

The visual processing done in recent years has proved to be more complex than what is required. A new system has been explored which utilizes the fourier transform of the images in order to analyze them from a different perspective. Using figures 3 and 4 (shown below) the old and new image processing methods are compared. The old code used many files and functions in order to determine the color, then the orientation of a simple line. By removing the blue water color in the background and taking the Fourier Transform of the image, the line perpendicular to the guide can be easily extracted, and the degree of orientation determined. This method uses fewer lines of code and can be used to identify many other shapes and obstacles.

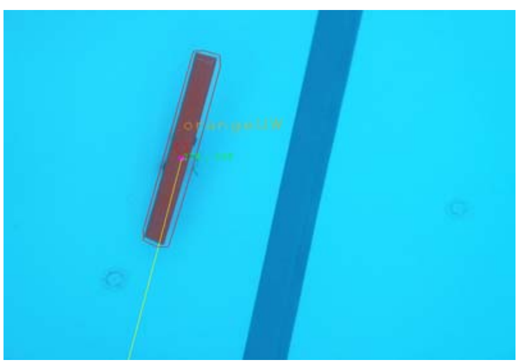

Figure 3: old image processing method

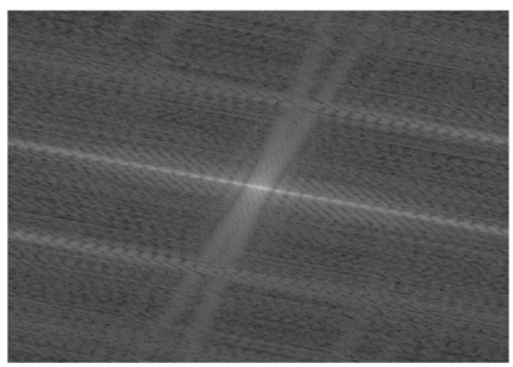

Figure 4: Fourier transform of Figure 3

The design of the torpedoes was conducted by researching the torpedoes used by the previous teams, and calculating the optimal design for the torpedoes given their size. The buoyant forces on the torpedoes was calculated using a mathcad file, as can be seen in Figure 5. The design of the torpedo was chosen based on the standard design of torpedoes, and the design chosen by previous teams' work. A model of the torpedo design can be seen in Figure 6. While calculating the size of the torpedo, a design was chosen that would allow the torpedoes to remain slightly under neutral buoyancy, so that their flight path in the water would be more suitable to an accurate path.

$Vol\_tor := 2.53635 \, in^3$

$Vol\_rod := 2.7611654 \cdot 10^{-2} \, in^3$

$dens\_tor := .038 \, \frac{lb}{in^3}$

$dens\_rod := 9.7912065 \cdot 10^{-2} \, \frac{lb}{in^3}$

$g = 9.807 \, \frac{m}{s^2}$

$W\_tor := Vol\_tor \cdot dens\_tor \cdot g$

$W\_rod := Vol\_rod \cdot dens\_rod \cdot g$

$W\_tor = 0.429 \, N$

$W\_rod = 0.012 \, N$

$W\_tot := W\_tor + W\_rod$

$\boxed{W\_tot = 0.441 \, N}$

$dens\_wat := 1000 \, \frac{kg}{m^3}$

$F_{b\_water} := (Vol\_tor + Vol\_rod) \cdot dens\_wat \cdot g$

$\boxed{F_{b\_water} = 0.412 \, N}$

Figure 5: Torpedo buoyancy calculations

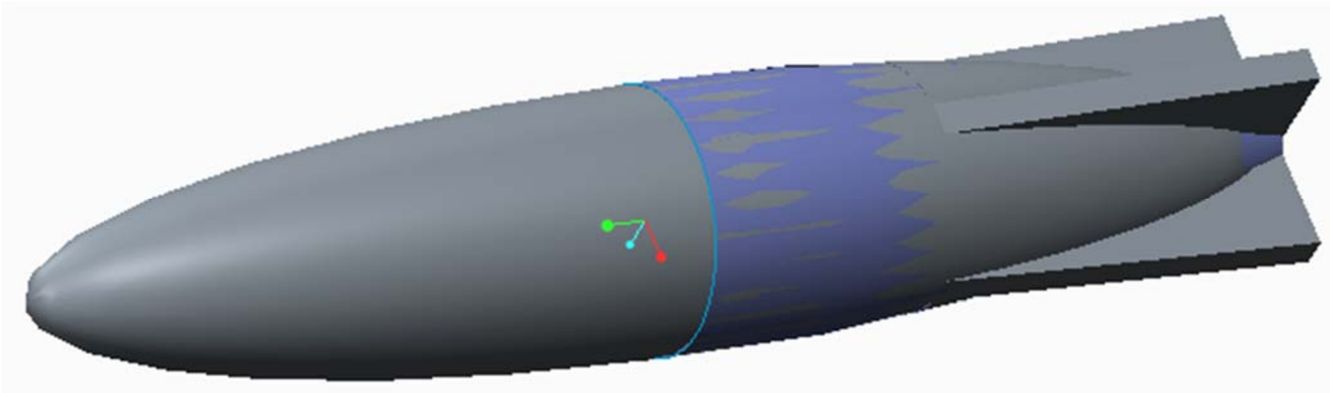

Figure 6: Torpedo Design

7 Conclusion

The sub constructed by this team has the ultimate goal of going to the AUVSI RoboSub competition next summer. With a proper schedule and allocation of tasks, the team can properly move forward with the design aspects of the RoboSub project. Many steps have already been taken in order to design a competition ready sub. Some subsystems are starting to take form while the fundamentals are being perfected. The collaboration of the ME and ECE RoboSub teams will aid significantly in the work that can be accomplished for this project. While the ECE team focuses on Coding and the internal components, the ME team can work on the external processes and mechanisms needed. The two teams are moving forward, preparing the sub to meet the requirements set up by the AUVSI foundation.

8 References

[1] AUVSI Foundation 2015 RoboSub Competition Rules and Mission http://higherlogicdownload.s3.amazonaws.com/AUVSI/fb9a8da0-2ac8-42d1-a11e-d58c1e158347/UploadedFiles/RoboSub%20Competition%20Official%20Rules%20and%20Mission%20-%202015.pdf

[2] Woods Hole Oceanographic Institution. https://www.whoi.edu/main/ABE

[3] Wiley Online Library. http://onlinelibrary.wiley.com/doi/10.1111/j.1559-3584.1992.tb02238.x/abstract

[4] FSU RoboSub User Manual. http://fsurobosub2015.weebly.com/uploads/1/0/3/7/10377608/user_manual.pdf

9 Biography

LaNeicia Gomez is a 22 year old undergraduate student at Florida A&M University. She is in her last year of studies to become a Computer Engineer. Alongside of her studies, she is a Peer Tutor for mathematics at FAMU. LaNeicia will contribute her knowledge of coding to this project.

Travis Hett is currently a senior studying at Florida State University. He is majoring in Computer Engineering. He is focusing on the digital image processing of the RoboSub.

Gabriel J Mendoza is a Computer Engineering Major at FSU, also pursuing minors in Computer Science, Mathematics, and Physics. Through courses taken, he has gained proficiency in VHDL, C++11, Assembly Code, and Microcontroller Programming, as well as with using the Linux interface and scripting.

Brandon Anderson is a senior pursuing a Bachelor of Science in Mechanical Engineering at Florida State University. He is the lead Mechanical Engineer on the team, and serves as a liaison between the ME and ECE RoboSub teams who are collaborating on the project.