Project Plans and Product Specification

Design and Development of an Autonomous Underwater Vehicle

Team 23

AUVSI Robosub

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1. Problem Statement

The AUVSI RoboSub is an annual competition held yearly amongst schools from around the country. Despite many attempts from previous senior design teams the FAMU/FSU college of engineering has yet to make an appearance at the competition. The most recent iteration of the sub design had several problems related to both the hull and the software. More specifically the sub was not completely watertight and the programming had not been completed. Furthermore sub systems such as torpedoes and claws had not been integrated with the sub and tested as a complete system. All of these problems must be addressed before continuing with last years design.

"The autonomous underwater vehicle is incomplete and unable to be brought to the upcoming competition."

2. Project Scope/ Goal

Goal Statement: "Redesign and improve upon last year's autonomous underwater robot making it capable of navigating an underwater course and accomplishing a variety of tasks set forth by the AUVSI competition."

3. Project Objectives

Objectives for this project are to focus on fixing the problems that were prevalent in the previous iteration of this project, while developing the subsystems needed for the competition. Problems include fixing problems with leakage in the frame, reducing the buoyancy in the hull of the AUV, and restructure the frame where the subsystems fit together.

4. Methodology

Due to the constraints in time for the upcoming competition, the team is following a schedule in which there will be ample time within the spring semester to test and debug the sub. A prototype version of this sub should be tested in a body of water before the end of the fall semester in December. Considering that this has been a project that multiple groups have handled in previous years, many components may be potentially salvaged from last year's sub.

This provides us with a significant advantage, allowing us to be ahead of schedule and giving us a jump start to our design process. However, before we proceed with building upon the previous model, it is necessary to test the components we plan to utilize and integrate into the system. Once a basic model is functioning, our focus can shift to debugging and installing hardware to complete the various competition tasks. In the past, the competition required submarine models to launch torpedoes and lift submerged items. Even though the specific requirements for the 2016 competition have not been updated yet, our model will likely be required to complete similar goals. Therefore, we will develop our project based on the previous requirements, yet have it remain flexible enough to implement further functions for unknown competition requirements. To further help with the task of deciding what subsystems should be evaluated and further developed the team decided to perform a more detailed House of Quality (HOQ) matrix. The HOQ will help to highlight what subsystems will be most important to the team to work on based off the requirements given by the competition and requirements that the team felt were important to the overall design as well. For the HOQ the team used a numbering system, with 1 being low priority, 3 being medium priority, and 9 going high priority, to determine how each engineering characteristic interacted with each customer requirement. The resulting HOQ can be seen in Appendix A. Based off this HOQ it was found that the three subsystems that needed to be focused on are the sensing components of the AUV, the electronics housing of the sub itself to protect the equipment, and the torpedo propulsion system.

5. Constraints

Table 1: Weight Restrictions

Table 1: Size and weight constraints on AUVs entered into the competition.

	Bonus	Penalty
AUV Weight > 125 lbs (AUV Weight > 56.7 kg)	N/A	**Disqualified!!!**
125 lbs ≥ AUV Weight > 84 (56.7 kg ≥ AUV Weight > 38 kg)	N/A	**Loss of** 250 + 5(lb – 125) 250 + 11(kg – 56.7)
84 lbs ≥ AUV Weight > 48.5 (38 kg ≥ AUV Weight > 22 kg)	**Bonus of** 2(84 – lb) 4.4(38-kg)	N/A
AUV Weight ≤ 48.5 lbs (AUV Weight ≤ 22 kg)	**Bonus of** 80 + (48.5 – lb) 80 + 2.2(22-kg)	N/A

This section describes the requirements and constraints for the design of the AUV as described within the rules for the 18th Annual International Robosub Competition[2] . These rules given are the requirements for the AUV to compete in the competition and thus are adequate constraints for the project.

Constraints

- The AUV weight must not exceed 125 pounds in air
- The AUV must be able to fit in a 6 foot by 3 foot by 3 foot box
- Torpedoes and Markers must be able to fit into a 2 inch by 6 inch space
- Torpedoes and Markers must have a dry weight of no more than 2 pounds
- Torpedoes must travel at a “safe” speed, a speed that will not cause bruises when it strikes a person
- The vehicle must be battery powered and the battery must not have an open circuit voltage that exceeds 60V
- The vehicle must have a kill switch that can be easily accessible
- All propellers must have shrouds that surround them and have at least a 2 inch distance between the spinning disk and the edge of the prop.
- The AUV needs to be buoyant by at least 0.5% of the sub’s mass when it has been shut off through the kill switch.

6. Deliverables

This section is a list of important task and deliverables that need to be met throughout the course of the project. The deliverables listed below are for the Fall 2015 Semester.

6.1 Weekly

- Meeting minutes
- Individual team member journals

6.2 Project Tasks

1. Project Planning
2. Test the subs recent condition
3. Verify subsystems required to get the sub into the water are operational (i.e. hull, thrusters)
4. Submerge the submersible
5. Develop subsystem components (i.e. mechanical arm, torpedoes, cameras, hydrophone, pressure sensor)
6. Re-submerge the submersible
7. Troubleshoot and debug kinks in subsystems and components
8. Polish the subsystems and all components for smoother operation

9. Final submersion of the Fall 2015 semester

6.3 Reports

- Code of Conduct (9/11/2015)
- Milestone 1: Needs Analysis and Requirement Specifications (9/25/2015)
- Milestone 2: Project Proposal and Statement of Work (10/09/2015)
- Milestone 3: System-Level Design Review
- Midterm Report I (10/30/2015)
- Initial Web Page Design (10/15/2015)
- Final Web Page Design (11/24/2015)
- Final Design Poster Presentation (12/1/2015)
- Final Report (12/1/2015)
- Team Evaluations (11/3/2015 and 11/24/2015)
- Spring 2016 Reports

6.4 Presentations

- Milestone 1: Needs Analysis and Requirement Specifications
- Milestone 2: Project Proposal and Statement of Work
- Milestone 3: System-Level Design Review
- Midterm Presentation I: Conceptual Design (Week of 10/19/2015)
- Midterm Presentation II: Interim Design Review (Week of 11/17/2015)
- Final Design Poster Presentation (12/1/2015)

6.5 RoboSub Competition

- The competition-ready AUV by summer 2016. • Introduction paper for competition
- Compete in competition in California in summer 2016.

7. Assign resources

7.1 Tasks assignments

There are many tasks our team will be involved with during the duration of this senior design project but many of the speed bumps within these tasks will not be known until further down the road. The delegation of tasks will not be on individual basis until we are deeper into the project. At this point more general subsections are being dispersed to smaller groups within our team whose knowledge is more suitable for the task. We've decided the most important tasks to get the sub up and running can be broken into three main areas; Thruster/navigation, cameras, and hull. The delegations of these tasks among members is as follows; Laneicia, Jordan and Max on Thrusters/navigation; Travis, Erik, and Gabriel on cameras; Ross, Corey, John, and Brandon on the hull. Once the completion of these tasks is verified the subsystem including the mechanical arm, torpedos, hydrophone, and pressure sensor can be tackled by our team. The delegation of tasks throughout this project will be as organic as possible. Individual team members are not restricted to certain subsystems. If there help's needed on another task they will transfer to that subgroup and the team will adapt to the changes made. With this ideology the development of our autonomous submersible should be efficient and our team, flexible. If this end up not being the case adjustments will be made as needed and our senior design project will proceed on schedule.

7.2 Major resources

Many resources are made available to our team through the College of Engineering, advisors, and AUVSI. Resources available through the college include things like funding, machine shops, and workspace. Our advisor will be Dr.Clark who will give technical advice over the course of the project. As the competition draws closer eventually our team will be in contact with the AUVSI foundation and competition organizers to get competition specifics and any additional resources that may be required at that time.

7.3 Scheduling

	Task Name	Duration
1	Project Planning	2 days
2	Test the AUV's Ability	2 days
3	Troubleshoot Subsystems	8 days
4	Submerge the AUV	2 days
5	Work on Components	14 days
6	Re-Submerge	2 days
7	Debug Errors	5 days
8	Polish Operation	10 days
9	Final Submersion	2 days

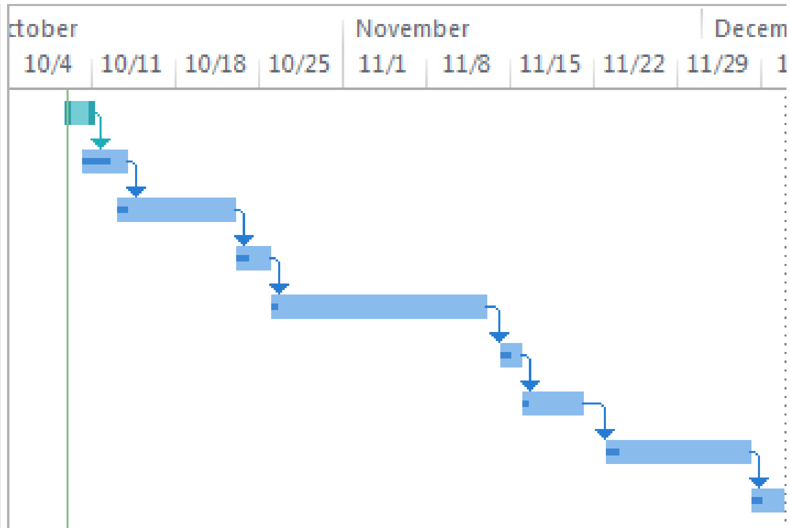

Figure 1: Gantt chart for the Fall 2015 semester

8. Product Specifications

8.1 Design spec:

8.1.1 Electrical Design Specifications

- Two microcontrollers: Arduino UNO and Arduino MEGA. Arduino UNO interacts and operates the depth sensor. Arduino MEGA is the primary control, interacting and operating thrusters and the inertial measurement unit
- Cameras that directly interact and operate with the main CPU

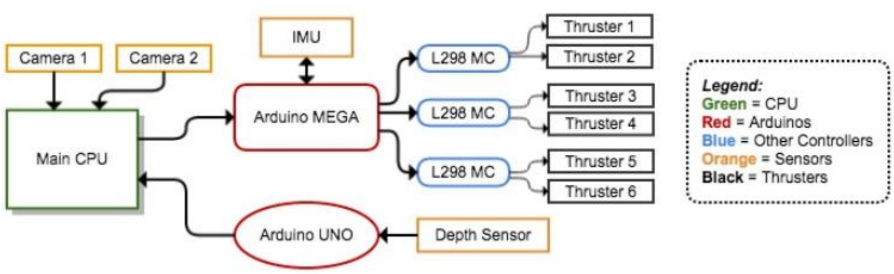

Figure 2: Electrical Component Mapping

8.1.2 Mechanical Design Specifications

- Six total thrusters
    - 2 longitudinal and 4 vertical
- Welded aluminum electronics housing with acrylic lid bolted over rubber seals
- 80/20 slotted aluminum frame

8.2 Performance spec:

Expectations of performance in the field or when used by consumer including: instrumentations output requirements (operation range, accuracy, resolution), display features, detection capability, energy and fuel consumption, data transmission, and efficiency.

8.2.1 *Data acquisition*:

The robot will receive data from a set of sensing apparatus. The primary source of sensing will be the two mounted cameras: one camera at the front of the sub and one at the bottom facing downward. These cameras will primarily be receiving color and shape information to tell the sub the action needed. The second is the data received from the IMU which give the orientation and acceleration of the submersible. The Third set of data is the pressure sensing so that the sub can adjust its depth based on changes in pressure readings. The final primary sensing device to gather external data is the acoustic sensor. The acoustic sensor which is needed to retrieve an object from the bottom of the pool.

8.2.2 *Actuation and Real World Outputs*:

The robot must interact with the outside world with both its movement and subsystems in order to complete the tasks. Principally, the motors are needed to be controlled individually so that the sub can move forwards, backwards, turn, reorient, and move laterally to efficiently maneuver through obstacles. This is paramount and must work with the camera inputs in order to accomplish the basics of every task. The next set of components are the parts necessary to complete the competition challenges. The first of these is a gripper mechanism designed to retrieve a objects from the bottom of the pool and resurface with it. This object must be constrained in at least three degrees of freedom. This gripper must also be able to lift the lid off of circular bins in order to place markers in them. The next output is the torpedo system which must be able to fire two separate shots through small windows based on camera inputs.

8.2.3 *Mechanical System*:

The core of the pure mechanical system of this sub is the hull. The hull must be monolithic and safely contain all of the electrical and thinking components. Waterproofing of this case is of the utmost importance in its design. The other key factors that must be taken into account in this design are weight, heat transfer, and the ability to interface between the internal and external electronics. The other portion of the pure mechanical system is the frame. The frame must hold the hull, motors, cameras, and other external submersible elements in place. Ideally the frame allows for the interchangeability of components and placement changeability for the purposes of testing.

9. References

1.) "RoboSub" AUVSI Foundation. Web. 25 Sept. 2015 <http://www.auvsifoundation.org/foundation/competitions/robosub>

2.) "RoboSub Competition Official Rules and Mission." *AUVSI Foundation*. Web. 26 May 2015.

10. Appendix

10.1 Appendix A

Table 2: HOQ

		Engineering Characteristics									
Units		ft^3	lbf	lbf	N/A	lbf	N/A	N/A	N/A	N/A	N/A
Customer Requirements	**Importance Weight Factor**	Dimensions	Buoyancy	Weight	Material	Thrust	Sensing	Frame	Electronics Housing	Torpedo Propulsion system	Gripper mechanism
Cost - $2000 budget	5	1			3	1	9	3	3		
Accessablity - easy to access components	4	9		3				3	9		
dimensions do not exceed 6x3x3 feet	3	9	3	3				3	3		
Durability	4				9			3	3	1	1
Shoot a target with torpedoes	4						3	3		9	
Place markers in bins	4						3	3			9
Waterproof	5				3			1	9		
Detect frequencies between 20-45kHz	5						9				
Navigation through obstacles	5	3	3	1		9	9	1	1		
Do not harm testers	5			3	1	3	1	1	3	9	3
Raw Score		83	24	41	71	65	164	75	137	85	55
Relative Weight %		10%	3%	5%	9%	8%	21%	9%	17%	11%	7%
Rank Order							1		2	3	