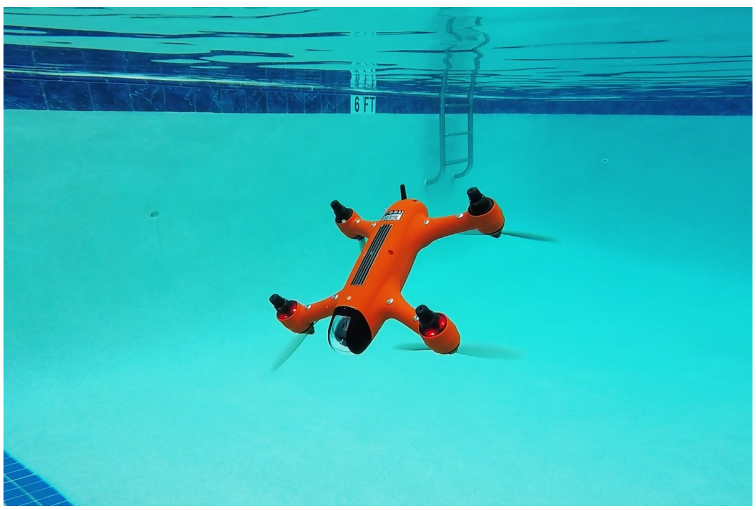
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

PROJECT CHARTER
CSE 4316: SENIOR DESIGN I
FALL 2021



THE DROWNING ROBOTS
IEEE TRASH ROV BOT

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Revision History

Revision	Date	Author(s)	Description
0.1	10.07.2021	HR, AP, JM, SW	Document creation
0.2	10.11.2021	HR, AP, JM, SW	Completed first draft of the charter

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1 Problem Statement

For the IEEE robotics competition, we are to design a water-based R.O.V. to collect trash from the ocean. The 'trash' can either be under the surface of the water, on the floor of the ocean, or on the surface of the water. To simulate this, the competition has two challenges. During the first challenge, our robot is to travel underwater through two hoops of varying sizes to go to a box. Inside the box is a 6-inch tall block with a hook at the top. Once the robot grabs the block, it is to travel back through the hoops and place it on a shelf that is located 6-inches below the surface of the water. After completing that, the robot is to travel to the opposite corner it started in to finish. During the second challenge, the robot is to hit a button on the side of a box to release 'trash' which are tennis balls. Once the tennis balls are released, our robot is to collect the tennis balls and deposit them into a box next to the shelf from the previous challenge. Upon completion of this task, the robot is to once again travel to the opposite corner from where it started at to finish.

2 Methodology

To solve this problem, we are going to build a water-based R.O.V. that is able to maneuver through the water with a combination of ballast tanks and propellers. We are going to use ballast tanks to control the angle at which the robot moves and the depth control for the robot. The propellers will be used for movement through the water, and, hopefully, movement through the air.

3 Value Proposition

This project will offer a robot design that can be operated to collect trash from the surface of the ocean and below the water. With the current state of world pollution, this robot will be an ideal solution on how we can clean our oceans from the trash we have dumped into it.

4 Development Milestones

This list of core project milestones should include all major documents, demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month.

Provide a list of milestones and completion dates in the following format:

- Project Charter first draft - 10/2021
- System Requirements Specification first draft - 11/2021
- Architectural Design Specification first draft - 11/2021
- Demonstration of waterproof design - 11/2021
- Demonstration of basic movement system - 11/2021
- Demonstration of depth control system - 12/2021
- Detailed Design Specification first draft - Month 2022
- Demonstration of fine movement system - 01/2022
- Demonstration of Demonstration of under water block pickup and placement - 02/2022
- Demonstration of under water tennis balls pickup and placement - 02/2022

- Demonstration of flight - 03/2022
- Demonstration of wireless communication - 03/2022
- Final Project Demonstration (Competition) - 04/2022
- CoE Innovation Day poster presentation - 04/2022

5 BACKGROUND

This robot is designed to compete in the 2022 IEEE Region 5 Conference. During this conference the particular competition that we are entering is a course made to test how well a drone can collect 'trash' from the ocean floor. To test the capabilities of the drones, the course was designed in a pool with obstacles to deal with and objects, representing trash, to collect. The perimeter of the pool will be 23 feet and 6 inches by 11 feet and 6 inches, while the depth will vary from 3 to 4 feet. The obstacles we can attempt to navigate though are two rings, one with a diameter of 32 inches and the other with a diameter of 28 inches, and two boxes, one with an open side and the other with a triggerable hinge. Also included in the field is a designated start area, designated stop area, and a trash receptacle box with a shelf. The competition is split up into two different rounds with each having a different goal and expected route. In the first round, with the drone starting within the starting position, it should proceed though both rings to the open box and collect the 3-pound block inside. After acquiring the brick, the drone should proceed back though the rings and deposit the block on the underwater shelf attached to the trash receptacle. Then all that is left to complete the round is to stop the drone in the finish location. In the second round, similar to the first round, the route begins in the start area but then proceeds to the hinged box where a button will have to be pressed in order for the box to open. After the box is opened, the tennis balls will be free to collect and deliver to the trash receptacle. After delivering all the tennis balls, the last thing that is left to do is end the round in the finish area. Completing all these tasks perfectly will award us a maximum of 110 points, maximum extra totaling 35 points awarded to light weight and low-cost designs, and .1 of a point for every second under the allotted 30 minutes to do each round. This competition will be held in 6 months on Saturday, April 2, 2022, at the Hilton Houston North Hotel in Houston, Texas.

6 RELATED WORK

We were unable to find any examples of an underwater drone to pick up litter whether for practical use or just research. However, there were many examples of drones for underwater video taking and as proof-of-concept research. Our first set of related work we found focused on the more fundamental considerations for building an underwater drone. From the commercial area we found the PowerRay [6], NEMO [1], and EXRAY [2] as good examples for thinking about our movement options underwater. While the PowerRay and NEMO seemed to have a few thrusters split between vertical and horizontal, the EXRAY seems to have more angled thrusters for the horizontal ones. Doing more research into this and how they waterproofed the drone may help us with ours. We then found research done by the University of Utah Underwater Robotics [4] and Rizvi College of Engineering [7]. These sources where far more technical and supplied us with necessary knowledge and equations for this project. After the planning to make the drone fly too, we picked up more resources on flying and submersible drones. We were able to find two research papers by Rutgers University [7] and Jeppiaar Engineering College [5]. Now while Jeppiaar's drone could be submersed, it was primarily only capable of taking off under water and being mobile in the air. However, the Rutgerâs drone has full three-dimensional movement about and bellow the water and switched between the two modes instantly. We also have a commercially produced drone called the Spry+ [3] that is another drone that has three-dimensional movement. With its spec sheet we are able to get a better idea of the parts we may need to order and brands to look into.

7 System Overview

Our design will have two levels of motion control: motion underwater, and motion in the air. Underwater, device movement will be controlled primarily by ballast tanks, which will allow for fine-tuned depth control, and rotatable thrusters, which will allow the device to propel forwards, backwards, left, right, up, and down. The device will move through the air using a system of propellers. This propeller system will also be used underwater to help with motion control; underwater, the device will be capable of rotating at a ninety-degree angle in order to allow the propeller to serve as a rudder to the ROV device and work in tandem with the thrusters. Since the use of a power supply cable provides us with the capability of having a high power output to our device, we will employ variable power dynamics to account for the differences in power consumption required by a device moving through air as compared to a device moving through water. We will use a lower power output to control the thrusters when the device is operating underwater, and then will significantly increase power to the propeller system once the device is ready to take flight after completing its underwater tasks. All main electrical components will be housed in a waterproof body, and any external components will be covered in a waterproof coating. In order to execute the two separate competition tasks, we will have two detachable components: a detachable block gripper for the first task, and a detachable netting system for the second. The detachable block gripper will be directly attached to the main body of the device in order to avoid having to deal with the mechanics of controlling a robot arm. Using the gripper in coordination with a camera system embedded into the device will allow us to secure the block either by hooking the ring attached to its top or by directly grabbing the center of the block itself. The detachable netting system will be used in coordination with the device's submerging and flight capabilities to gather as many tennis balls as possible for completion of the second task. Finally, the device will be operated remotely through a user control interface, most likely in the form of a controller, which will allow the user to dictate mode of operation (flight or water mode), power output, submerge depth, direction of motion, and detachable component control to the device, and will also allow the user to view the output of the device's embedded camera system. Given enough time, we may also attempt to build the device with an autonomous power supply and wireless communication capabilities.

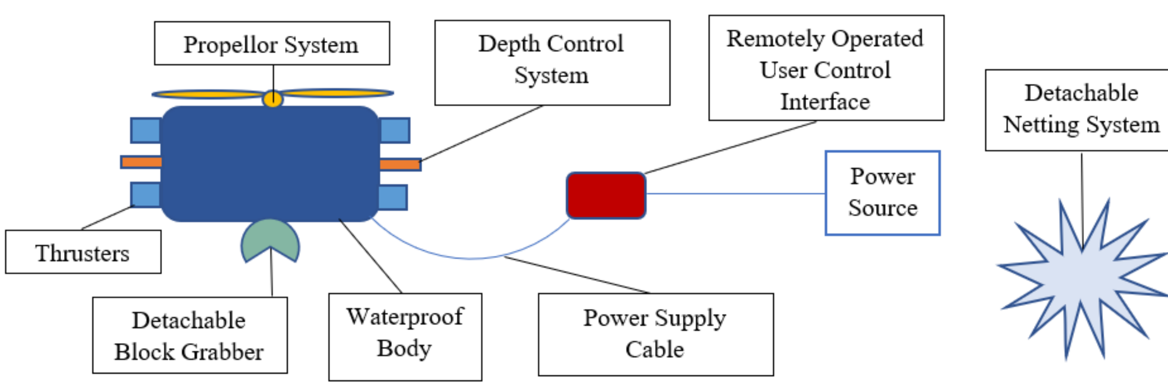

Figure 1: Design diagram

8 Roles & Responsibilities

The University of Texas at Arlington, Professors Conly and McMurrough, and the team members will be the stakeholders for the project. Joanne Mathew will be the point of contact for the project. The team members are Joanne Mathew (CpE major), Sean Walter (CpE major), Hunter Redhead (CS major), and Apar Pokhrel (CS major). Sean and Joanne will be in charge of hardware design and hardware control software, and Apar and Hunter will be in charge of integrating user control into the system. Dr. Conly and Dr. McMurrough are considered our Product Owners for this project. The role of scrum master will be alternated among team members based on sprint goals over the course of the project.

Specific roles:

- Hunter Redhead: managing our GitHub
- Apar Pokhrel: maintaining reporting documents
- Joanne Mathew: updating workflow in Linear
- Sean Walter: maintaining our Discord server

9 Cost Proposal

Major expenses in this project will be primarily due to securing components. We plan to use either freely available software development tools or free lite versions of paid platforms for our software development and task-flow management, such as Notepad++, VS Code, GitHub, and Linear. Fabrication equipment in the CSE Makerspace and SD labs is also freely available to us since we are SD students.

9.1 Preliminary Budget

Item	**Cost (US Dollars)**
Thrusters (x8)	211.60
Propellers (2CW, 2CCW)	6.99
Wire (8 AWG, 30ft)	100.74
Tubing (3/8"ID, 10ft length)	10.99
PVC Piping (1/2"ID, 5ft length)	10.19
Waterproof Coating (300g tub)	17.97
Cameras (x4, Mini)	75.96
Motors (2CW, 2CCW)	38.99
Mechanical Claw/Gripper Robot with Servo Motor	32.99
Netting (50'x50')	28.99
Total Cost: (tax not included)	535.41

Table 1: Budget table listing main component costs

9.2 Current & Pending Support

Our only funding source for this project is the CSE department; our funding has been secured by Dr. Conly and Dr. McMurrough, and we currently have at our disposal a total budget of $800, with the potential to increase that budget as needed if it is deemed necessary.

10 Facilities & Equipment

One of the major challenges we face right now is that we will need a proper testing area for our drone. It would have to be a pool at least a couple feet deep and open for us to use and put obstacles in for at least a few hours at a time. Currently to solve this we are thinking of maybe getting an above ground pool or working out something with the school or a near by appartment complex in order to get access to their pool. Besides a testing ground we will need a general lab space for construction and storage of our drone. We plan on using the senior design lab for this. In terms of tools we plan to use the 3D printers on campus at the moment as well as general construction tools for putting together the drone.

11 Assumptions

The objective of the IEEE Robotics Competition is to demonstrate the use of a tethered underwater robot to collect "trash" from the ocean floor, mid-water, and surface. The game field simulates an underwater environment containing objects such as industrial, infrastructure, and underwater debris.

The following list contains critical assumptions related to the implementation and testing of the project.

- A suitable swimming pool location (indoor/outdoor) will be available that resembles the Game Field to test the preliminary and future prototypes.
- The underwater and surface obstacles and anomalies will represent typical operational challenges.
- Design parts and hardware will be available within the estimated time interval.
- The host will provide ample power and consistent network connectivity at the Game Filed site.
- A preliminary design prototype will be delivered at the end of the final sprint cycle.
- The competition rules and requirements will not change during the development of the prototypes and the final deliverable.

12 Constraints

The 2022 IEEE Robotics Competition lays out a large number of constraints ranging from team structure, size and weight of the ROV, capabilities, competition rules, deadlines, and general requirements.

The following list contains key constraints related to the implementation and testing of the project as detailed by the IEEE Robotics Competition and Senior Design class.

- A team should consist of no more than 5 and no less than 2 undergraduate students.
- An Intent to Compete must be submitted by Wednesday, December 1st, 2021.
- The Competition Day will be held on Saturday, April 2nd, 2022. All teams must be registered before Monday, February 28th, 2022.
- The robot must weigh 30.0 pounds or less, including the tether and any additional devices when attached.
- The robot must fit inside a 20" x 20" x 20" cube while occupying the START and FINISH location.
- Total development costs must not exceed $800.
- All team members and the robot must adhere to the rules of the Game-play and Order of Operations

13 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Delays in delivering preliminary design prototype for testing	0.40	14	5.6
Outdoor testing swimming pools are not available.	0.30	15	4.5
Ample power supply and consistent network is not available at the Game Field.	0.30	9	2.7
Delays in shipping from local and overseas vendors	0.40	20	8.0
Changes in the competition rules and general requirements	0.20	15	3.0

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The Project Charter will be updated as needed at the end of each sprint; it will require editing primarily as we finalize our system design. The first draft will be delivered at the end of the first sprint and the final draft will be delivered by the end of the last sprint.

14.1.2 System Requirements Specification

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

14.1.3 Architectural Design Specification

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

14.1.4 Detailed Design Specification

Describe how this document will be maintained and updated (how often, under what circumstances, etc.). When will the initial version be delivered? When will the final version be delivered?

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added to the backlog by what we as a team deem reasonable during our meetings. Decisions will be made by a group vote and will mostly depended on the order of importance for the competition that we deem each item to have. Back log will be maintained on the Linear software with Joanne as the overseer.

14.2.2 Sprint Planning

There will be a total of four sprints this semester. There will be an interim week between the end of a sprint and the beginning of the following sprint that we will use as a team to plan each upcoming sprint.

14.2.3 Sprint Goal

We will decide our sprint goal(s) as a team. We do not have a direct "customer" for this project as we are participating in a competition; hence, our sprint goals will be based on which aspects of our prototype remain to be constructed or improved in order for us to successfully execute required competition tasks to our satisfaction.

14.2.4 Sprint Backlog

The sprint backlog will be kept up to date by the team during the meetings for the most part. We will be using Linear to keep track of our sprint backlog. Joanne will be the overseer for our Linear software but making sure it is up to date is a responsibility of the group.

14.2.5 Task Breakdown

Tasks will be handed out based off of the personal preference of the members. If there are no volunteers for a task, then whoever is leading the meeting will delegate it to whoever they deem most suitable. Assigned responsibilities for each member will be on our Discord server for all to see and we will have a bot for logging the hours members spend on their tasks.

14.2.6 Sprint Burn Down Charts

Who will be responsible for generating the burn down charts for each sprint? How will they be able to access the total amount of effort expended by each individual team member? What format will the burn down chart use (include an example burn down chart below).

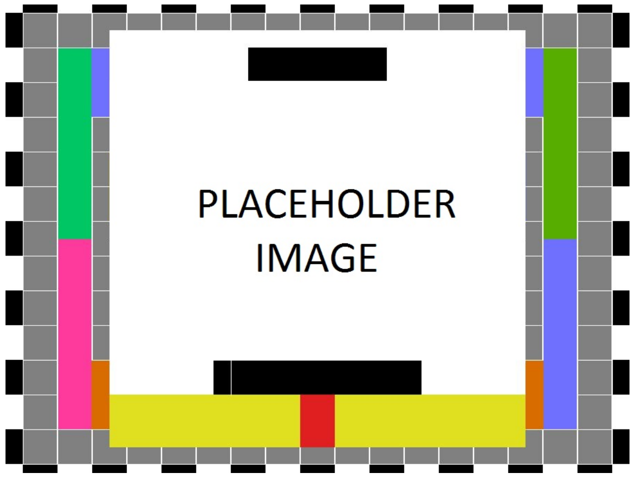

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

How will the sprint retrospective be handled as a team? When will this discussion happen after each sprint? What will be documented as a group and as individuals, and when will it be due?

14.2.8 Individual Status Reports

What sort of status will be reported by each individual member, and how often will it be reported? What key items will be contained in the report?

14.2.9 Engineering Notebooks

How often will the engineering notebook be updated, at a minimum, by each team member? What is the minimum amount of pages that will be completed for each interval, and how long will that interval be? How will the team keep each member accountable? Who will sign of as a "witness" for each ENB page?

14.3 Closeout Materials

The following materials, in addition to major documentation deliverables, will be provided to the customer upon project closeout. Remove this paragraph from your draft, but leave the heading.

14.3.1 System Prototype

What will be included in the final system prototype? How and when will this be demonstrated? Will there be a Prototype Acceptance Test (PAT) with your customer? Will anything be demonstrated off-site? If so, will there be a Field Acceptance Test (FAT)?

14.3.2 Project Poster

What will be included on the poster, what will be the final dimensions, and when will it be delivered?

14.3.3 Web Page

What will be included on the project web page? Will it be accessible to the public? When will this be delivered? Will it be updated throughout the project, or just provided at closeout (at a minimum, you need to provide a simple web page at the end).

14.3.4 Demo Video

What will be shown in the demo video(s)? Will you include a B-reel footage for future video cuts? Approximately how long will the video(s) be, and what topics will be covered?

14.3.5 Source Code

How will your source code be maintained? What version control system will you adopt? Will source code be provided to the customer, or binaries only? If source code is provided, how will it be turned over to the customer? Will the project be open sourced to the general public? If so, what are the license terms (GNU, GPL, MIT, etc.). Where will the license terms be listed (in each source file, in a single readme file, etc.).

14.3.6 Source Code Documentation

What documentation standards will be employed? Will you use tools to generate the documentation (Doxygen, Javadocs, etc.). In what format will the final documentation be provided (PDF, browsable HTML, etc.)?

14.3.7 Hardware Schematics

Will you be creating printed circuit boards (PCBs) or wiring components together? If so, list each applicable schematic and what sort of data it will contain (PCB layout, wiring diagram, etc.). If your project is purely software, omit this section.

14.3.8 CAD files

Will the project involve any mechanical design, such as 3D printed or laser-cut parts? If so, what software will you use to generate the files and what file formats will you provide in your closeout materials (STL, STEP, OBJ, etc.). If your project is purely software, omit this section.

14.3.9 Installation Scripts

How will the customer deploy software to new installations? Will you provide installation scripts, install programs, or any other tools to improve the process? Will there be multiple scripts provided (perhaps separate scripts for the graphical front end and back end server software)?

14.3.10 User Manual

Will you customer need a printed or digital user manual? Will they need a setup video? Decide now what will be provided and discuss.

REFERENCES

[1] Aquarobotman nemo underwater drones that can fly.

[2] Exray â hydromea.

[3] Spry+.

[4] Utah underwater robotics.

[5] Bharat Kungwani and Noopoor Misal. Design and fabrication of a low cost submersible ROV for survey of lakes. 04(9):7.

[6] pvadmin. PowerRay underwater drone | explore the underwater world.

[7] Khan Obaidur Rahman, Taushif Shaikh, Sayed Saad, Chowdhry Uzair, Husain Jasdanwalla, and Ameya Nadkarni. DESIGN AND FABRICATION OF UNDERWATER VEHICLE. 03(5):7.