EML 4552/EEL 4915C: RoboBoat 2020

Critical Design Review: Updated Project

Team Introductions

Brandon Bascetta
Mechanical Design Lead

Courtney Cumberland
Manufacturing Lead

Toni Weaver
Systems Lead

Team Introductions

Madison Penney
Electrical Design Lead

Mark Hartzog
Software Lead

Peter Oakes
Integration Lead

Advisors

<u>EE Mentor/Academic Advisor</u>
Dr. Geoffrey Brooks
Electrical Engineering,
FSU Panama City

<u>ME Mentor/Academic Advisor</u>
Dr. Damion Dunlap
Mechanical Engineering,
FSU Panama City

Brandon Bascetta

Advisor

<u>Technical Advisor</u>

Dr. Joshua Weaver

Senior Scientist of Autonomy, NSWC

Brandon Bascetta

Objective

Create a new boat for the 2020 RoboBoat competition.

Peter Oakes

Project Scope

The scope of this project is to manufacture and wire a competition ready boat. This project will also involve basic software for the future RoboBoat competition.

Peter Oakes

Project Requirements

- Boat shall be positively buoyant.
- Boat shall be manufactured to withstand normal use during testing and competition.
- Boat shall have all necessary sensors integrated into hull.
- Boat shall be wired up and competition ready.
- Boat shall contain custom power box.
- Boat shall have basic motor mixing and RC control.
- Boat shall be capable of basic waypoint navigation.

Madison Penney

Work Breakdown

- Sensor Design - Brandon
- Manufacture - Courtney
- Power – Madison/Peter
- Sensor Integration - Peter/Toni
- Software – Mark/Toni

Madison Penney

Risk Assessment

Linked WBS/IMS ID#	Owner	Type of Risk	Status	Risk Event	Likelihood Consequence Rating	Risk Mitigation Strategy	Risk Identified Date	Risk Approval Date	Planned Closure Date	Target Risk Rating
4.5	Toni	Budget	Open	If funding is not received from Fsu-Famu Mechanical engineering department. Then materials must be obtained from another source.	L = 1 C = 4	Toni will rearrange budget	3/1/2020	3/30/2020	4/12/2020	L = 1 C = 2
9.2	Courtney	Budget	Open	If material cannot be purchased from cheapest place, then the material a higher priced source will be needed.	L = 1 C = 3	Courtney will find alternative sources	3/11/2020	3/30/2020	4/12/2020	L = 1 C = 2
12.1	Brandon/ Toni	Performance	Open	If physical testing of the boat is not possible, then the software cannot be tested on the boat.	L = 5 C = 5	Brandon/Toni will set up a virtual test environment	3/13/2020	3/30/2020	4/12/2020	L = 5 C = 2
15.1.2	Madison/ Peter	Performance	Open	If the power box cannot be manufactured, then it cannot be used within the boat.	L = 4 C = 3	Madison/Peter will wire the boat without the power box	5/26/2020	5/27/2020		L =3 C =1
14	Mark/Toni	Schedule	Open	If the boat cannot be manufactured in time for testing, the software may not be verified.	L = 3 C = 5	Mark/Toni will test software using simulation	5/20/2020	5/27/2020		L=3 C=1

Toni Weaver

Project Inspiration

Mark Hartzog

Project Inspiration

Roboboat is an autonomous boat competition, created by Robonation and Sponsored by Office of Naval Research, Naval Information Warfare Center as well as by several corporations.

Mark Hartzog

Project Inspiration

SEMINOLE COAST

Last year, a team of FSU and Gulf Coast students participated in RoboBoat's 2019 competition

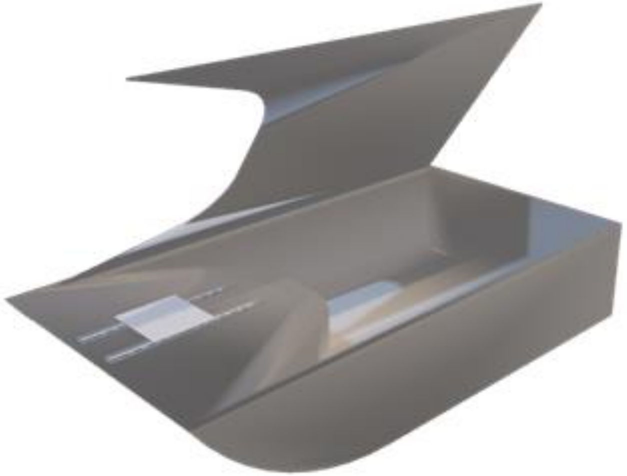
Mark Hartzog

Boat Manufacturing Plan

Courtney Cumberland

Previous Work: Boat Hull

The original boat design was modeled off of the Boston Fire Boat. This boat design is a hybrid of a catamaran and a monohull, drawing from the benefits of bots.



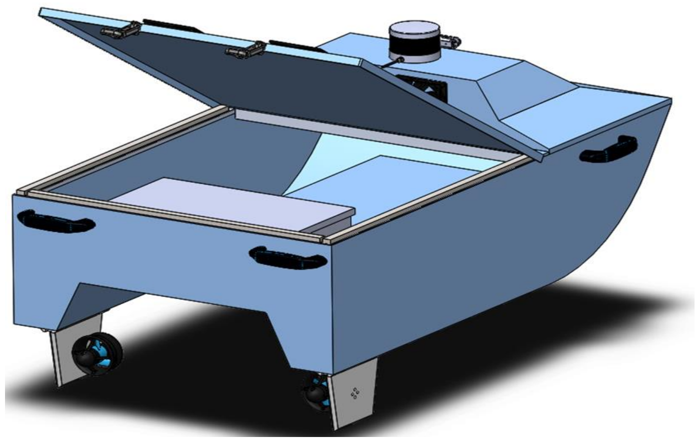
Initial Boat Design

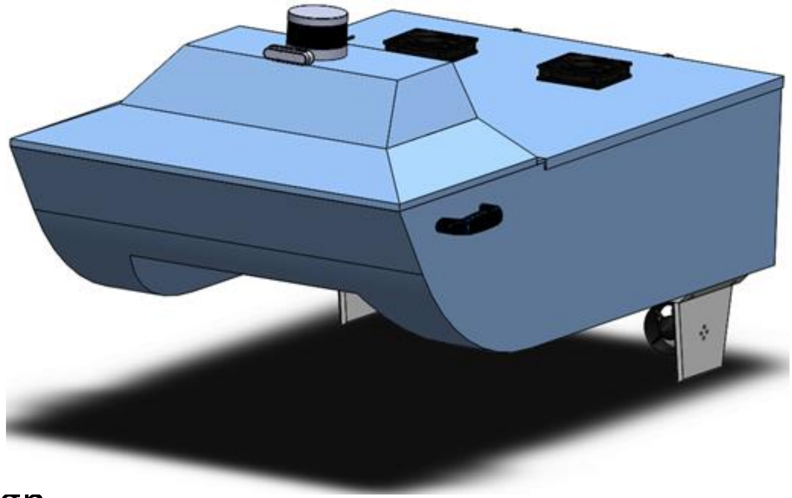
The original boat was 32” X 60”. In order to better visualize the size of the boat, a model was made out of cardboard.

Courtney Cumberland

Previous Work: Boat Hull

After building the cardboard boat, the original boat was found to be too large. A second version was created, which became the final design of the boat. The new boat dimensions are 30” X 50”.



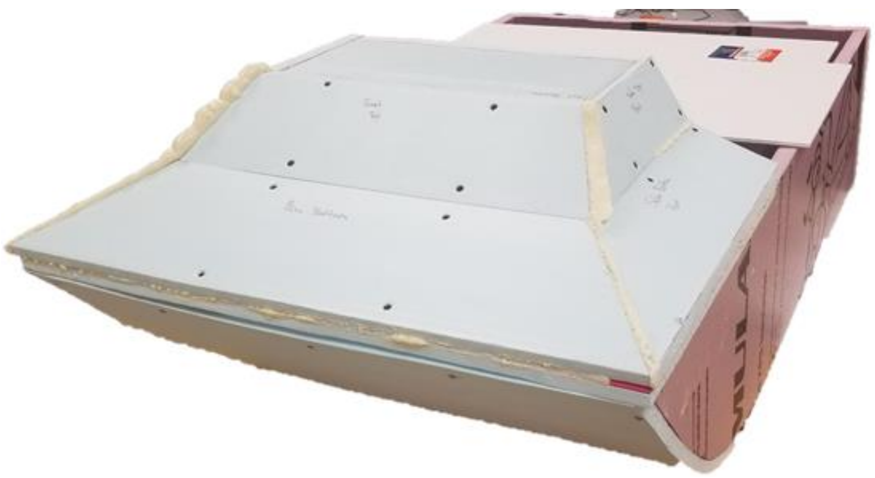


Final Boat Design

Courtney Cumberland

Previous Work: Boat Hull

To manufacture the boat, a boat mold hull was created using 1” and ½” foam. The foam pieces of the mold are connected with drywall screws. Sanded spray foam and modeling clay are used to fill in the gaps and it will be covered with packing tape. There are two unconnected sections, the top and the bottom that will be created individually and then joined together.



Boat Hull Mold

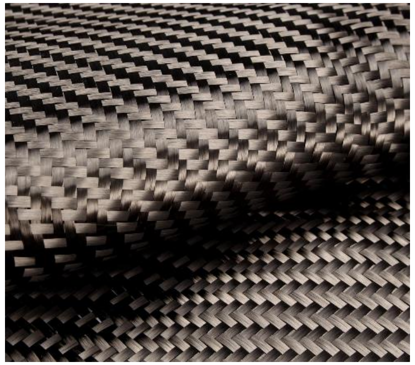
Courtney Cumberland

Material Selection

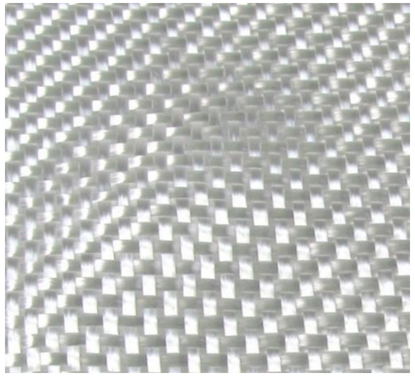
<u>Material Choices</u>:

- Wood
- Metal
  - Steel
  - Aluminum
- Molded Plastic
- Composites
  - Carbon Fiber
  - Fiberglass
  - Kevlar Cloth

Composite Cloths



Carbon Fiber



Fiberglass

Kevlar Fabric

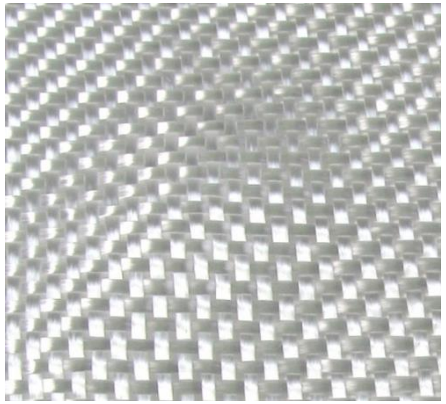
Courtney Cumberland

Selected Material: Primary

6 ounce Plain-Weave E-glass Cloth and Fiberglass Mat!!

Plain Weave Description:

- Weight : 6 oz per square yard
- Thickness: 0.0093”
- Weave: 1 over-1 under



Mat Description:

- Weight : 13.5 oz per square yard
- Thickness: 0.013”
- Weave: omnidirectional

Reasons:

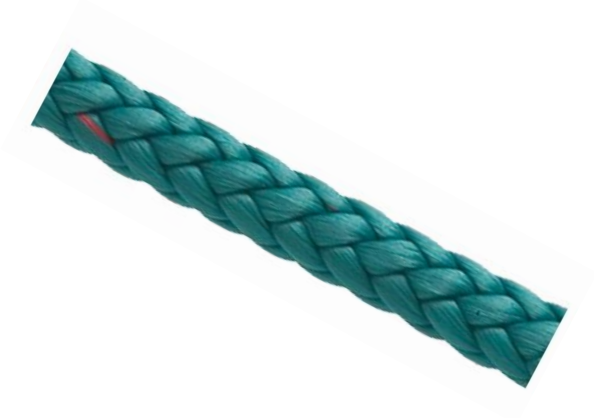
- Low Cost
- Easy manufacturability
- Anti-Corrosive
- High strength to weight ratio

Courtney Cumberland

Selected Material: Secondary

Epoxy Resin System

Lid Latches



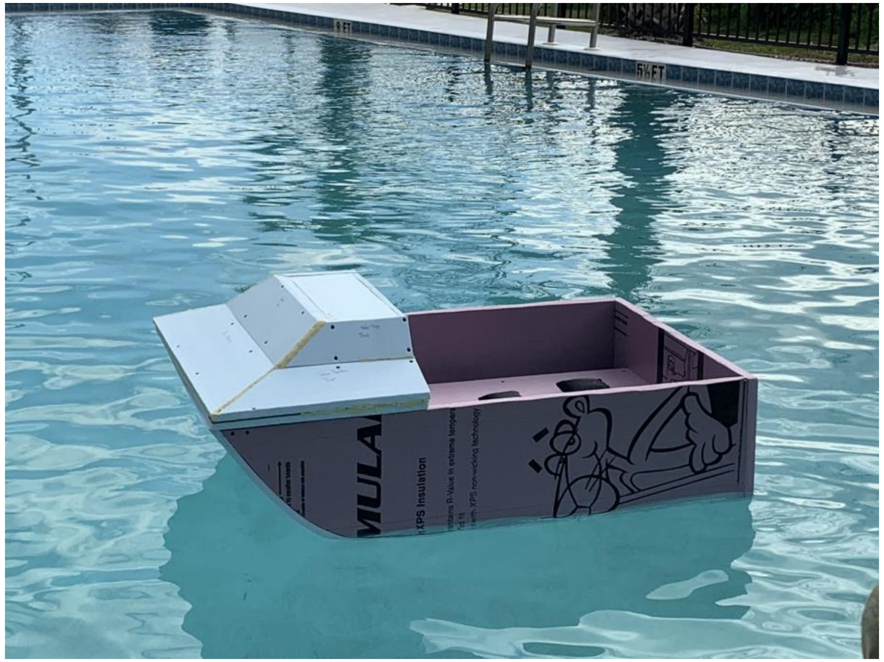
Green Harness Line

Handles

Courtney Cumberland

Manufacturing Plan

To manufacture the boat hull, a foam mold was created for the top and bottom sections. It was tested for buoyancy in a pool and floated while supporting 12 pounds of weight. Next the fiberglass cloth and fiberglass mat layers will be applied with epoxy resin. Three layers of cloth and one layer of mat will be used. The cloth will have grainline directions of 0º, 45º, 90º, one layer each. The fiberglass mat does not have a grainline direction. The fiberglass hull will then be removed from the mold and sanded down to a smooth finish. The final step will be to paint the fiberglass with a marine grade paint.



Courtney Cumberland

Boat Wiring and Device Integration

Peter Oakes/Madison Penney

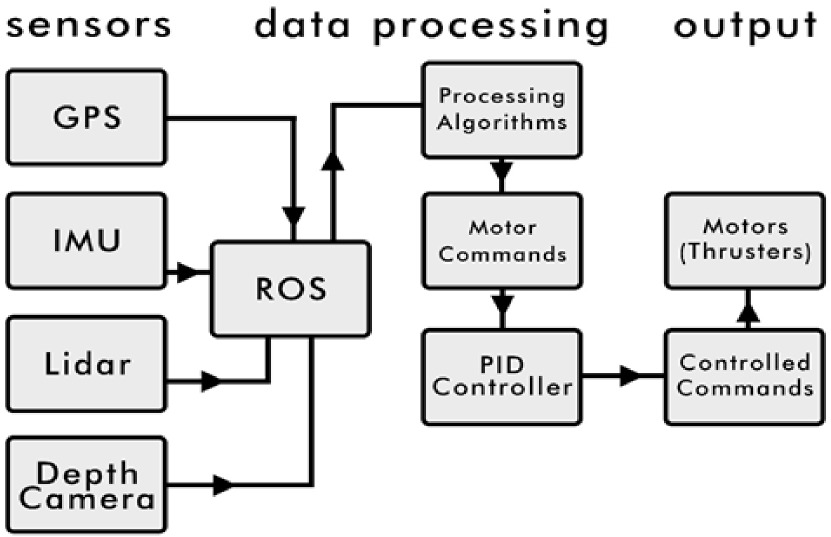
Hardware: Objectives

- Make sure power is providing correct voltages
- Make sure all the necessary sensors/computers run on power system
- Make sure IMU chip is calibrated and working with software
- Any other unused components are accounted for
- Ethernet for computers/LiDAR, and Wi-Fi for the rest

Peter Oakes

Hardware: Sensor Breakdown

To begin the testing and prototyping of the software, the hardware needed to be assembled. For our team the hardware specifically consisted of sensor devices, networking devices, microprocessors, and computers. These sensors needed to be wired to the computer using USB and network connections as seen in the figure to the right.



Peter Oakes

Sensors: LiDAR

This device constantly rotates during runtime while simultaneously firing infrared lasers. It allows us to map our environment in real time and is helpful in object detection.

Peter Oakes

Sensors: VectorNav VN-300

This device provides extremely accurate readings for heading, position, velocity, and acceleration from satellites so that it is not dependent on the vehicle dynamics.

Peter Oakes

Sensors: Intel RealSense

The device allows us to use computer vision algorithms using the OPENCV libraries. Specifically it allowed us to characterize buoys using the software algorithms.

Peter Oakes

Components: Networking

For our uses, we needed to establish a connection to our computer onboard, our ground station computers and our LiDAR. To do this, we used an ASUS networking router which provided very high speeds over ethernet and Wi-Fi connections. Components with higher priority (i.e. computer, LiDAR) that required faster connections were connected via ethernet.

Madison Penney

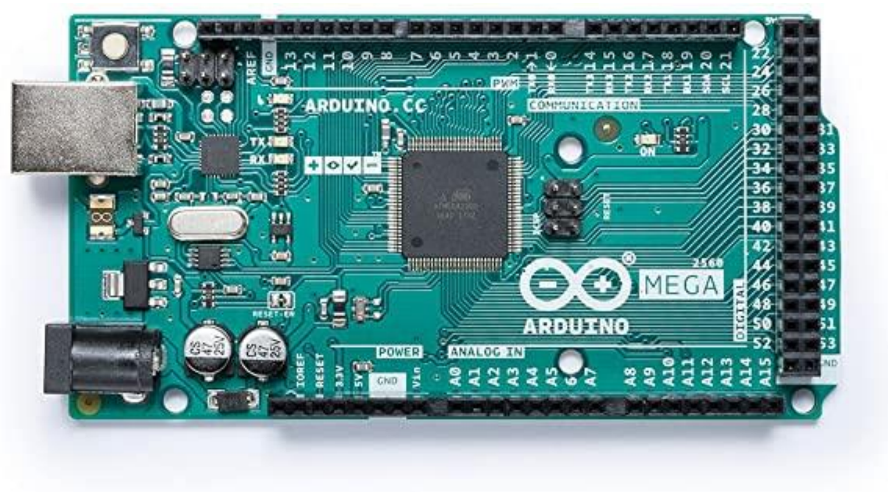
Components: Computer

To run our more processing intensive tasks like vision and path-planning algorithms, we decided to use a mobile station called a Simply NUC developed by Intel. It uses an x86 architecture and consumed a small amount of battery which worked out perfectly for our uses.

Madison Penney

Components: Microprocessor

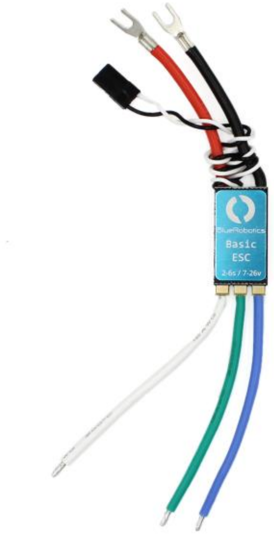
To run the tedious tasks that usually requires constant input like motor drivers or a digital killswitch we used the open source Arduino MEGA boards because we could directly code in C++. The boards performed exactly to our expectations and never provided any issues during runtime.



Madison Penney

Components: (ESC) Electronic Speed Controls

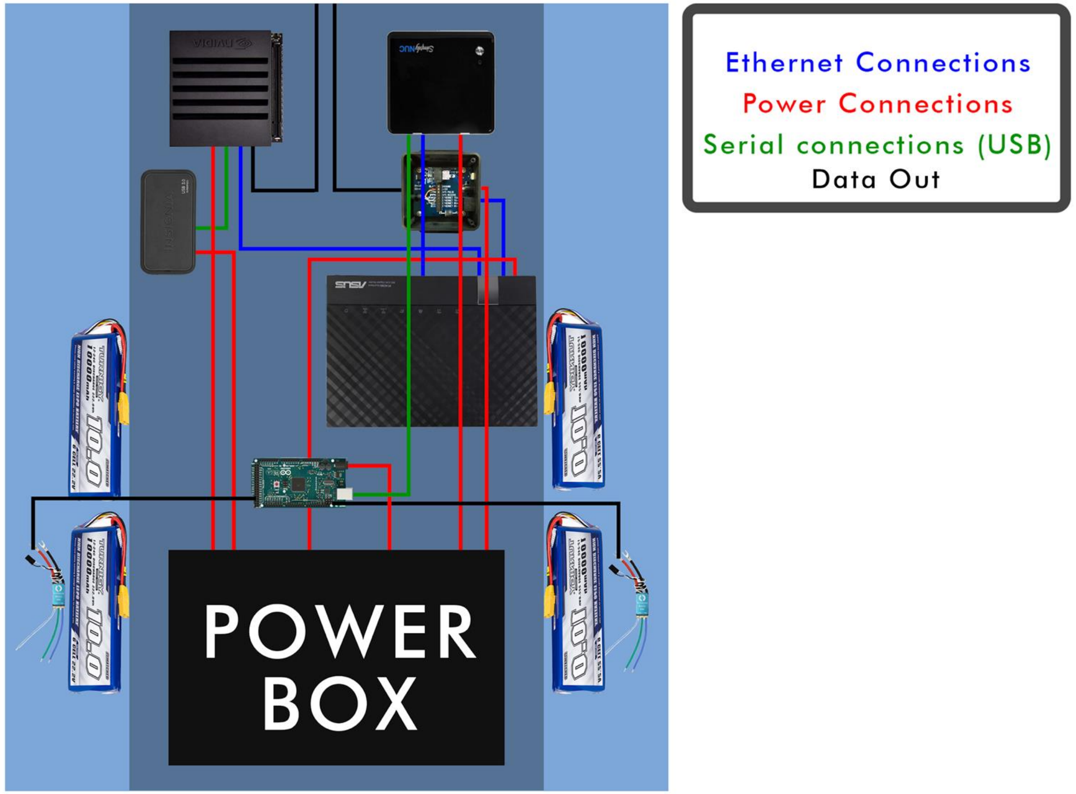
The device used to send motor commands from the arduino was an electronic speed controller. This device takes in a pulse width modulation (PWM) signal. The width of the pulse of the signal will be related to a particular current to bias the motors for thrust.



Madison Penney

Wiring Schematic

To the right is a diagram explaining the layout of the sensors of the boat and how they work together. The power box, constructed by another senior design team, feeds power to all of the sensors. These sensors include the ones mentioned above, such as the LiDAR, depth camera, etc., as well as the router. The router provides ethernet connections to the LiDAR data box and computers, and Wi-Fi to the base stations. Finally, the motor drivers receive power from the power box and provide data commands to the electronic speed controls (ESC), which control the motors. Not pictured is the other Arduino MEGA that was used for the kill switch.



Madison Penney

Power Requirements

Device	Voltage	Current
Computer #1	19 V	
Computer #2	19 V	
LiDAR	24 V	3 A
Router	19 V	5 A
ESCs (x2)	16 V	24 A
Arduino Mega (x2)	9 V	2 A
DC Fan	12 V	5 A
USB Hub (includes RealSense camera)	12 V	5 A

Madison Penney

Sensor Design

Brandon Bascetta

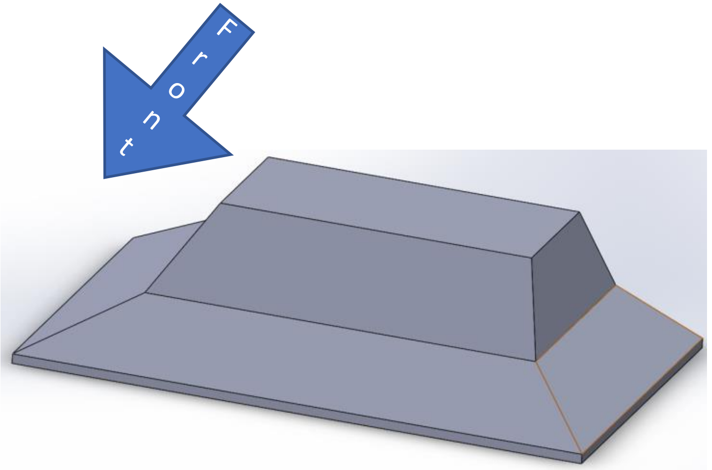
Sensor Design

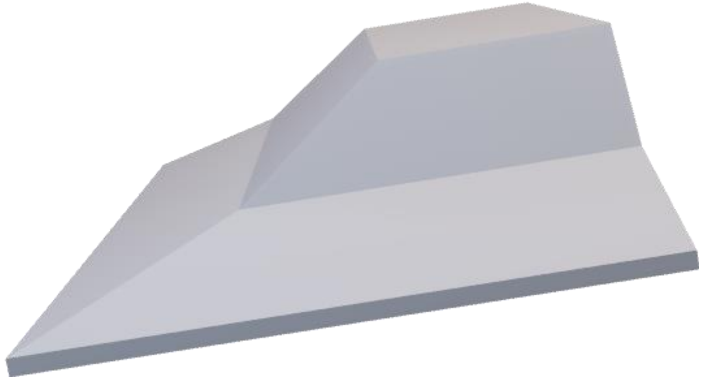
- Sensors that need to be integrated include:
  - D435 Intel RealSense Depth Camera.
  - Ouster OS1 LiDAR.
  - LED strip for visual feedback.

Brandon Bascetta

Sensor Design

- Method:
  - Measure current mounting points for sensors.
  - Design within a CAD Program (SolidWorks).
    - Modularity.
    - Adjustable.
    - Future proof.
  - 3D print parts for prototyping/final assembly.
    - Using PLA and PETG.





Brandon Bascetta

Software Development

Toni Weaver/Mark Hartzog

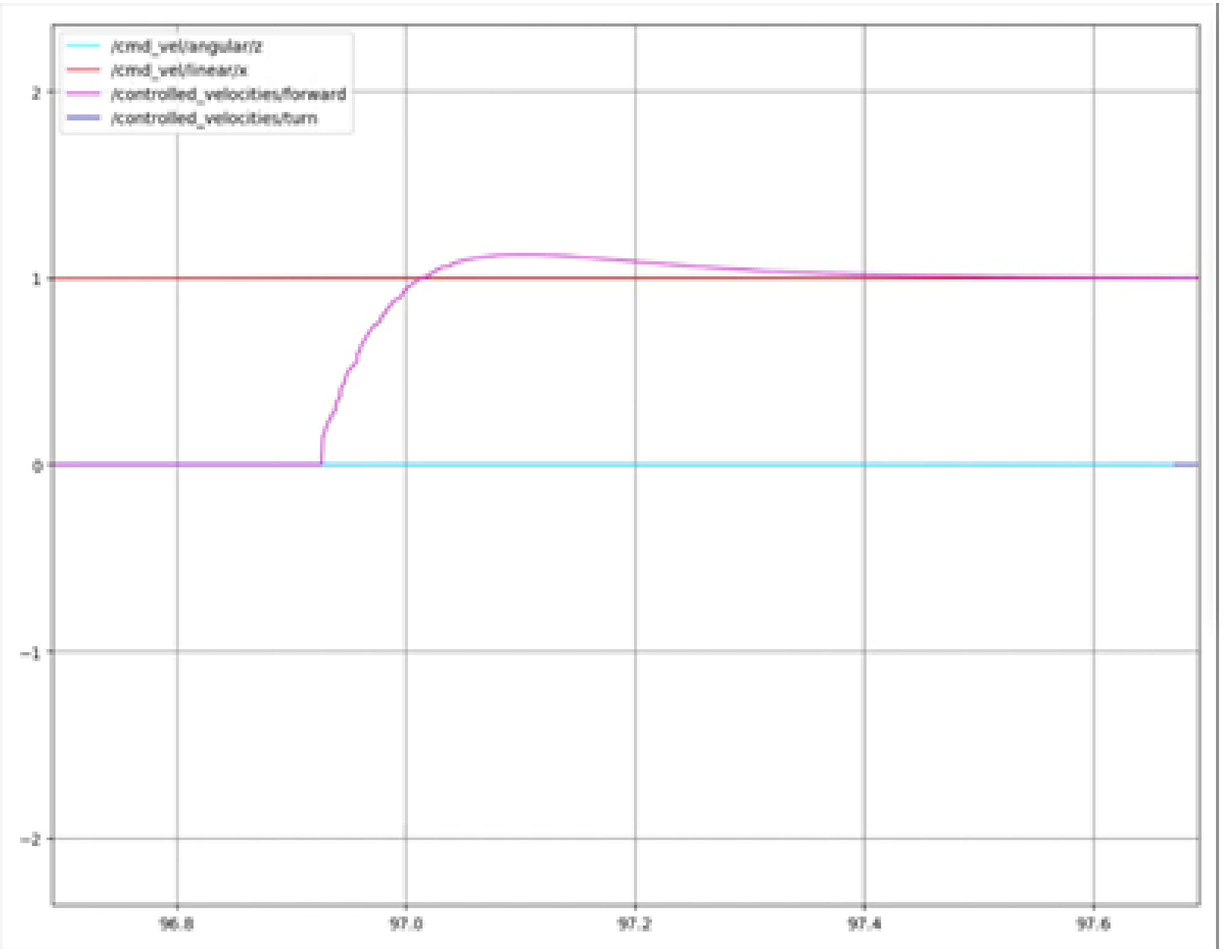
Software Environment: Robotic Operating System

All of our code was developed for use within ROS, or the robotic operating system. This system environment is open source. In our case we used much of the ROS namespace, classes and syntax. This includes functions that exist only in ROS, sensor manufacture packages that allow ROS to use various devices and open source ROS packages like Movebase, or Navigation that make our jobs easier so we can focus on the path planning aspect and vehicle control.

ROS.org

Mark Hartzog

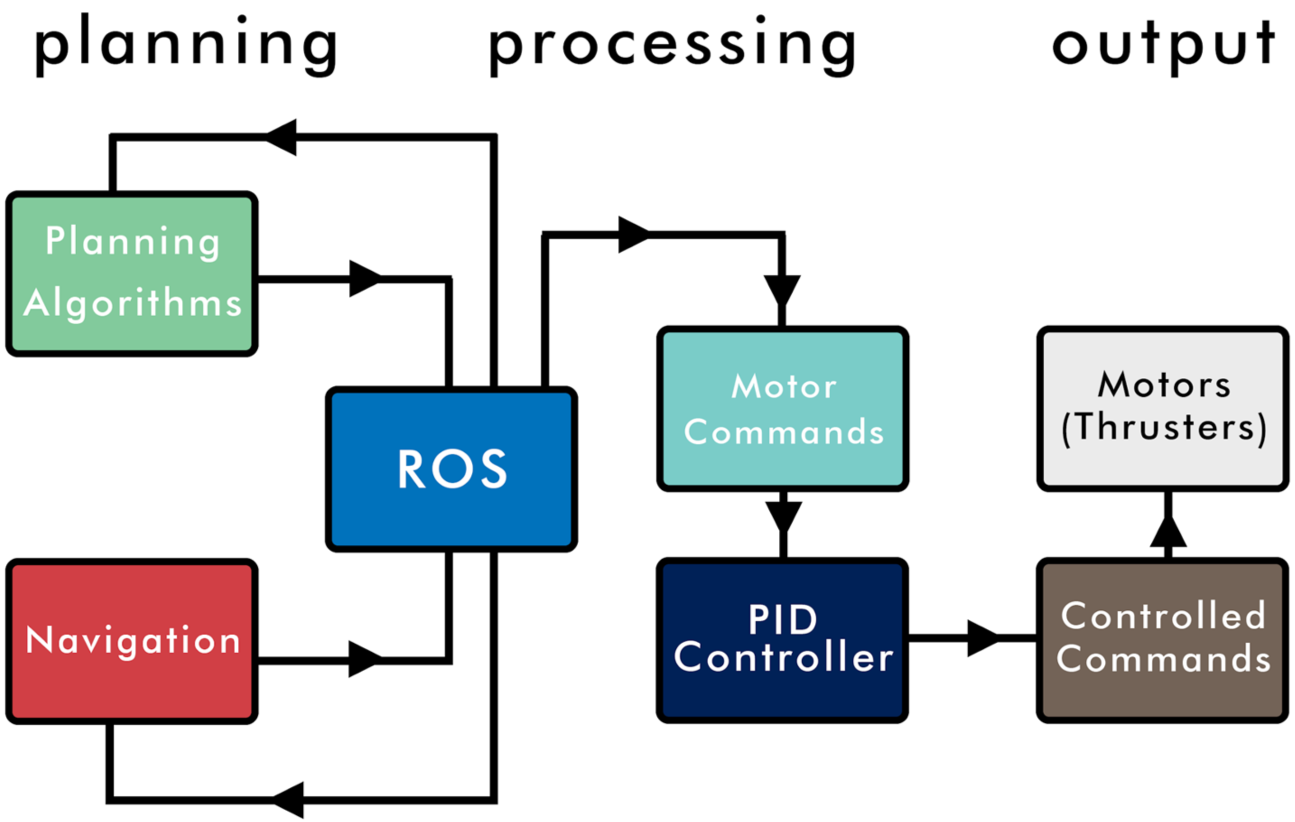
Boat Tasking: Control System (PID)



Last semester the team was successfully able to construct a PID implementation controller within the ROS environment. The controller was written in C++. The functionality of the controller is great when it implemented in simulations. However, this controller needs to be tested and tuned on our hardware. This will be our objective this semester regarding the controller. Additionally, it will allows us to get a good feel on how our boat will handle the movement through the water.

Mark Hartzog

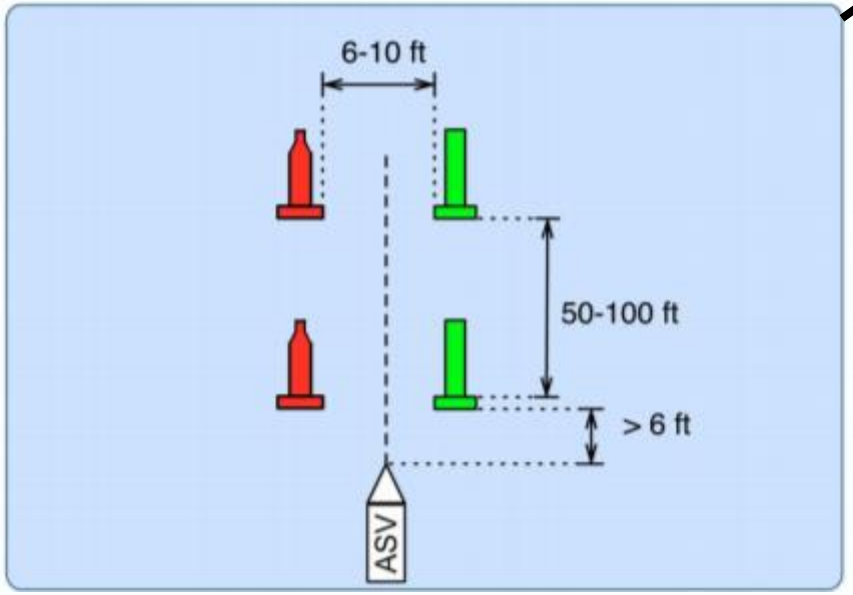
Boat Tasking: Data Path



Much like the flow chart from earlier, this one specifically illustrates the way that ROS takes in data from the sensors, then distributes it to the software applications. After this is done, the modified data is sent from the planning algorithms back to ROS. Finally, ROS takes that data and ferries it to the motors.

Mark Hartzog

Boat Tasking: Software



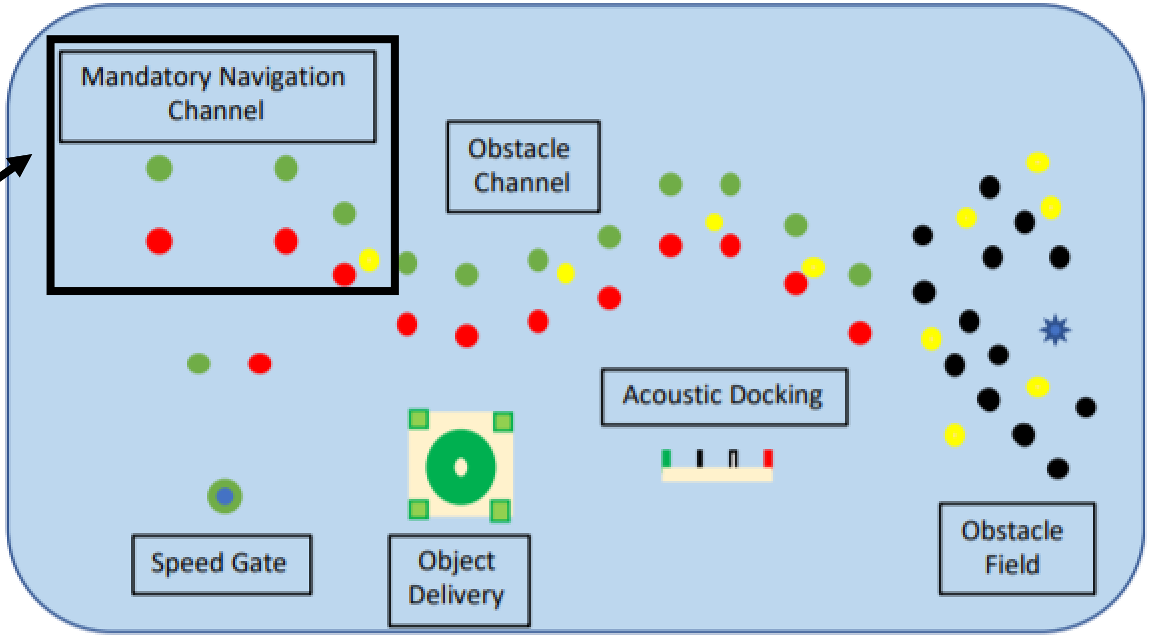


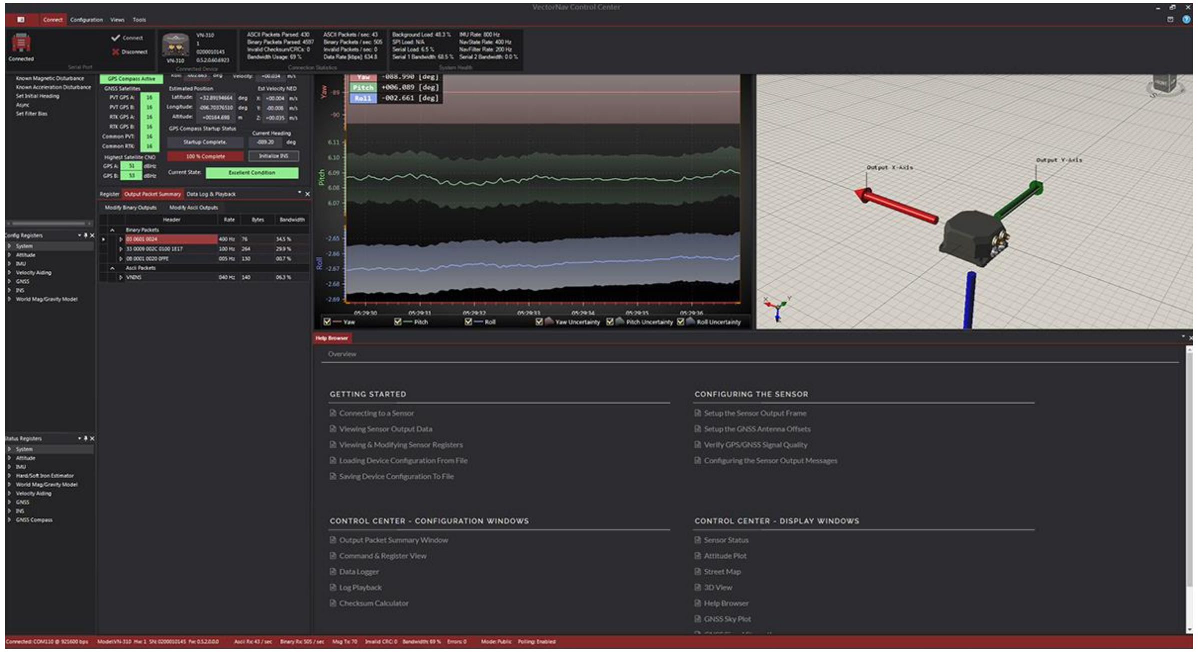
Figure 4: Sample course layout

We plan on focusing on localizing the boat in a coordinate frame within ROS and accomplishing the mandatory task (navigation channel) with software algorithms.

Toni Weaver

Boat Tasking: Sensors

The software portion of the project will be accomplished using two sensors, the Ouster lidar and the VectorNav VN-500.

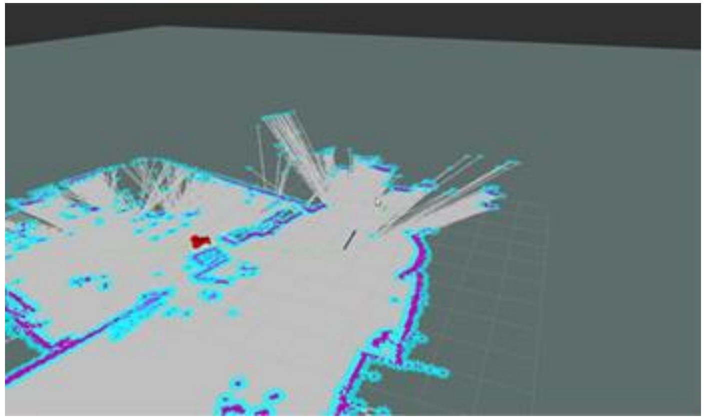


Using the VectorNav dashboard, shown here, the sensor will be calibrated. After the sensor is fully calibrated, it will be integrated with the navigation algorithms used within ros to help the boat know where is it within the environment. This will assist with path planning.

Toni Weaver

Boat Tasking: Sensors

The Ouster lidar will be integrated into ROS to use with our navigation algorithms. This will allow us to scan the environment to find where the obstacles/objectives are located. This will be used in conjunction with our navigation software in order to assist in path planning for the boat.



A photo of our LiDAR mapping out the Holley building in real time.

Toni Weaver

Boat Tasking: Hardware Testing

The Tank

While the final boat is being manufactured, testing will be done using our test boat nicknamed, “The Tank.” After the final boat is made, the testing will be done using that boat.

In order to maintain social distancing, team members will be joining the testing via Zoom, and all data will be collected and shared with the team virtually.

Toni Weaver

Conclusion

Hardware:

- Sensor mounts will be modular, manufacturable, and adjustable.
- Hull will be constructed when materials arrive
- Power system and wiring will be set up to provide correct voltages to each sensor

Software:

- Focus will be on solving the mandatory navigation channel task
- Boat will be localized using the VectorNav IMU and Ouster LiDAR
- Software will be tested initially using a test boat and then the final boat.

Courtney Cumberland

Questions??

Thank You for your time.