Design Document

Team: Camp Riley
Project: Sailboat

September 19th, 2016

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1. Table of Contents

2. Revision History

Date	Contributors	Revisions
October 3, 2013	Patrick Kennedy, Grant Prindiville, Katelyn Lennon	Created design document
October 8, 2013	Patrick Kennedy	Added detail to document
November 19, 2013	Grant Prindiville, and Katy Lennon	Added detailed design section
December 2, 2013	Patrick Kennedy and Katy Lennon	Added links to SharePoint
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3. Design Status Summary

Phase 1: Project Identification	**Status: Completed**
Gate 1: Continue if have identified appropriate EPICS project that meets a compelling need for the project partner.	
Date of Advisor approval:	

Phase 2: Specification	**Status: Completed**

Development	
Gate 2: Continue if project partner and advisor agree that you have identified the "right" need, specification document is completed and no existing commercial products meet design specifications.	
Date of Advisor approval:	

Phase 3: Conceptual Design	**Status: Completed**
Gate 3: Continue if project partner and advisor agree that solution space has been appropriately explored and the best solution has been chosen.	
Date of Advisor approval:	

Phase 4: Detailed Design	**Status: In progress**
Gate 4: Continue if can demonstrate feasibility of solution (is there a working prototype?). Project Partner and advisor approval required.	
Date of Advisor approval:	

Phase 5: Delivery	**Status: Incomplete**
Gate 5: Continue if Project Partner, Advisor and EPICS Admin agree that project is ready for delivery!	
Date of Advisor approval:	

Phase 6: Service / Maintenance	**Status: Incomplete**
Gate 6: Project Partner and Advisor approve continued fielding of project. If not, retire or redesign.	
Date of Advisor approval:	

4. Project Charter

4.1 Description of the Community Partner

The project partner for this project is the Bradford Woods, but we are also working closely with Camp Riley and CHAMP Camp. The overall mission of the project partner is to provide outdoor activities and enrichment experiences that encourage challenge and success, and foster independence for children and adolescents with tracheostomies, those requiring technological respiratory assistance, and other physical disabilities. The group that will benefit from this project would be the children attending summer camps at Bradford Wood, namely CHAMP Camp and Camp Riley. All campers would benefit from the universal design of this project. The main project partner, Bradford Woods, will be receiving the deliverables for this project.

4.2 STAKEHOLDERS

The stakeholders who will be affected by this project are Bradford Woods staff, CHAMP Camp counselors and campers, Camp Riley counselors and campers, parents of the campers, the instructor on the boat, Indiana University (owners of Bradford Woods), Purdue University, investors, and the American Camp Association. Also, any other camps, including those hosted outside of Bradford Woods, and the larger community of people with disabilities would be part of our stakeholders. Those who have a vital interest in the project's success is Purdue EPICS, CHAMP Camp, Bradford Woods, any camper attending the camp, and any parent of the campers.

4.2.1 Stakeholder and User Profiles

Campers **-** The direct users of the boat. The needs of the campers are an easily accessible boat that is operable by a variety of methods for instance a sip and puff switch, joy stick, etc. The boat also needs to ensure the user's safety by both being able to stand the weight of the camper as well as have a stable center of gravity in which the camper will not capsize up to a certain threshold of motion. Universal design will ensure all campers have access to the sailboat.

Counselors **-** There will be 2 of them with 1 camper on the sailboat at all times. They are there to ensure safety when loading and unloading campers, as well as while sailing. They are there to control the other functions not addressed by the function being used by the camper and are also ready to override said function if such an act becomes necessary for the safety of the camper and themselves. Also, they are ready to go to one side or another depending on which side needs more weight to prevent and correct keel. In the event that there is no wind to propel the boat, the counselors will use onboard oars to paddle in, or throw a tow rope in if the boat proximity allows for such an action. Finally, the counselors are responsible for setting up and storing the boat before and after use.

Bradford Woods – The sailboat could be used for multiple purposes. Not only could it be used for the CHAMP Camp but it could also be used for Camp Riley and other camps at Bradford Woods. It is a universally accessible camp so the sailboat needs to be able to be used by everyone. It also needs to be low maintenance and withstand average wear-and-tear. The counselor-camper ratio also needs to be maintained so 3 people need to fit in the boat at one time. Other waterfront activities at Bradford Woods are canoeing, pontoon boating, adaptive water skiing, swimming, and fishing.

Camp Riley – The sailboat could be used for a challenge day activity for the campers. The campers choose a challenge which they wish to tackle during one day at camp. The campers can sail with 1 or 2 counselors.

CHAMP Camp –It needs to be unable to flip or tip over, use a sip and puff switch to navigate, and have a place for ventilators which would need to be in a waterproof bag (already in use at Bradford Woods). There needs to be room for at least 3 people on the boat: 2 counselors and 1 camper.

4.2.2 Specific Camper Profiles

Timmy, 12 years old – He can walk around well until getting tired around half a mile or so. He does not own a chair but takes a couple minute break when tired. His motor function is very limited, as his thumbs point downwards and this limits his ability to pick up objects in the horizontal plane (Figure 4-1). For the last 4 summers, Timmy has attended camp and feels most comfortable there where he feels like he fits in among the other campers. He mentioned that while he and his brother were at Camp Riley, his parents went down to Disney World with their other siblings. He loves NASCAR and has a dream of racing cars in the future. He has cognitive ability slightly below age 12. He slurs his speech but it is still mostly comprehensible.

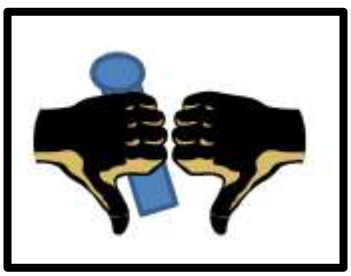


Figure 4-1: How Timmy holds objects

Jennifer, 7 years old – She uses a power wheelchair full-time as she has mobility from the neck up. She uses a sip and puff switch to control her chair and has a ventilator to aid her breathing. Jennifer wants a pirate theme for the sailboat and wants to learn to sail because so far she has only been canoeing. Her cognitive ability is appropriate for her age but she has trouble speaking.

Rachel, age 16 – She has an invisible disability. She uses an inhaler in the morning and a CPAP during the night. She is very active and loves to participate in activities like swimming and enjoys helping her fellow cabin mates when they need a drink of water. She is very supportive and encouraging towards other campers who are reluctant to try new activities.

4.3 Project Objectives

The purpose of this project is to modify an AMF Alcort Puffer sailboat with universal adaptive control in order to allow more children with physical disabilities to experience sailing. The modified sailboat will allow the children to be more independent, develop self-esteem, and broaden their experiences at camp.

4.4 Outcomes and Deliverables

The project outcomes will be a complete detailed design of the mechanism, which will be used to make the sailboat universally adaptable. We will also create a user manual for the mechanism, which will help future EPICS teams understand the design we have created. We will provide safety and stability (on land and on water) and camper seating options and way to attach depending on which we choose.

4.5 Overall Project Timeline

We have tested all systems on their own and plan to have all systems integrated by December 2016 and can perform testing in the Spring semester. We expect the sailboat to be delivered by May 2017 so the camp can integrate it into their program.

To look at our GAANT Chart go to page 20 of this document. (Click here to be taken there)

5. Goals and Requirements

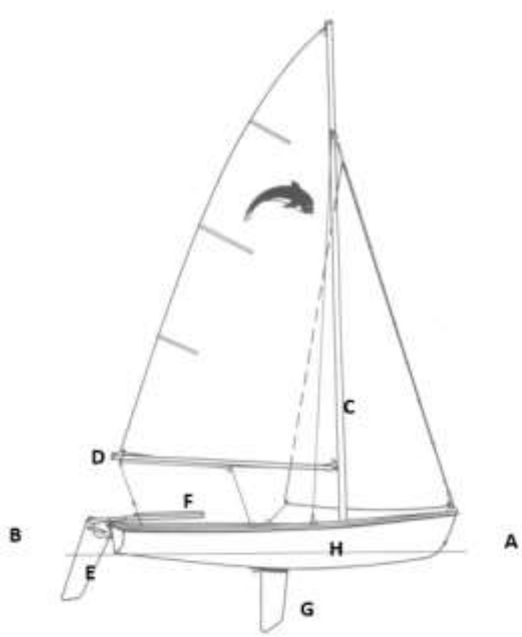
The goal of the sailboat project is to deliver a product that allows campers with physical disabilities to control a sailboat while remaining safe and comfortable. In order to accomplish this goal, we identified three main requirements for an adaptive, waterproof design: steering, seating and safety.

Requirements for the steering control include a manual override, sufficient range of motion of the tiller, sufficient speed of actuation, adaptable user interfaces, a waterproof system or system enclosure, battery life long enough to accommodate how long the boat will be used, and easy access to the motor compartment for battery replacement and maintenance.

The seating requirements identified include trunk support, a padded cushion, sufficient legroom, forward visibility, clearance of mainsail boom, waterproof material and still leaves space for 2 counselors onboard.

For safety, the requirements identified are insurance against capsizing, prevention of keeling too far while sailing, sufficient stability in water or for loading on land, and general safety of loading and unloading.

All of these specifications will be discussed further on in the Design Documentation.



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Sailboat Introduction

1.1 Boating Basics

A sailboat has two main movements: tracking and jibing. Tracking is aligning the boat with the wind when moving upwind. A boat is said to be tracking when the bow is pointed within ninety degrees of the wind. Jibing happens when the boat is going downwind and turns its stern through the wind so that the wind direction changes sides.

Figure 6.1-1: AMF Alcort Puffer

Sailboat Terminology (Reference)

A. Bow – front of boat
B. Stern – rear of boat
C. Mast – vertical pole
D. Boom – horizontal, swinging pole
E. Rudder – moveable steering fin
F. Tiller – handle to steer rudder
G. Centerboard – removable stabilizing fin
H. Hull – body of boat

Keeling – banking of hull

6.1.2 Boat Dimensions

In order to be able to make accurate prototypes, we took several dimensions of the sailboat (Table 6.1-1).

Table 6.1-1: AMF Alcort Puffer Dimensions

Object	**Parameter**	**Dimension (in)**	**Footnote**
Back Lip	Max Depth	2	
Back Lip	Flat Depth	1	
Rudder	Length	35	
Rudder	Width	9.5	
Back Lip To Tiller	Height	1.25	
Seat To Tiller	Height	9.25	
Trough To Seat	Height	7.5	
Trough To Boom	Height	42	
Centerboard	Height	37.75	
Seat Back	Height	7.5	
Stern	Outer Edge	40	
Stern	Inner Edge	28	
Tiller	Max Swing From Inner Edge	20.5	Figure 6.1-1
Tiller	Neutral From Inner Edge	14	
Tiller	Width	1	
Tiller	Height	1.5	
Tiller	Length	32.5	

Bow To Stern	Midline, Outer Edge	151	
Bow To Stern	Midline, Inner Edge	138	
Seat	Width	8.5	
Inner Edge Port To Inner Edge Starboard	Width	24.75	
Seat To Boom	Height	28	
Centerboard Seat	Height, Facing Stern	1.375	
Centerboard Seat	Height, Facing Bow	0.625	
Water Level To Top Of Rudder	Height	11	

Figure 6.1-2: Max tiller swing from inner edge

6.2 STEERING

6.2.1 Specifications

Bradford Woods already has an adaptive waterfront program, and are looking to expand. After the donation of a small sailboat it was decided that it would need to be modified somehow to allow the use of adaptive controls. The goal with the adaptive tiller control was to allow a wide range or persons to have at least some control over the boat and to lay the groundwork for future teams to further adapt the boat, should there be a desire. The team wanted to accomplish several main goals, which were influenced by time spent at camp and with the sailboat. Adaptive tiller control was the primary purpose, tied with safety.

It was clear that having safety with no control was just as unacceptable as having control with no safety. Knowing a counselor would be present during all boating, adding a manual override to the system was the clear safety mechanism of choice. This same mechanism would allow for easy control mode switching between motor operated adapted controls and manual tiller control with challenge day activities in mind.

Requirements	**Sources**
• Sufficient range of motion of mechanism	• Learned to sail and qualitatively determined what was a sufficient range of

• ±40º from neutral • Neutral Position = 90º	motion
• Sufficient speed of mechanism • Full range swing in less than 1 second	• Learned to sail and qualitatively determined what was a sufficient speed
• Manual override necessary	• General failsafe
• Wide range of users operating controls (Joystick + sip and puff) • Modes include various stepping increments and continuous operation	• Observed campers using joysticks on power chairs • Designed to mimic power chair operation
• Attachments for user interface need to be interchangeable. • Sip-n-Puff and joystick will interface same way	• Sailboat will be used be children from both Camp Riley and Champ Camp
• System is water-resistant/waterproof	• Experiences while boating indicates that water will get into the boat
• Sufficient battery life	• Aiming for 12 hours of continuous operation
• Easy to recharge battery	• Battery may be physically removed or kept within casing for recharging
• Easy access to steering system • System components will be compartmentalized within casing	• Design team acknowledges that the counselors may need to open the system regularly for battery charging and troubleshooting

6.2.2 Findings and Recommendations

The first summer design team was leaning towards a cable attached to a cart, riding a track, guided by pulleys, powered by a DC motor. It was referred to as the closed loop gear motor and pulley system, this design allowed for compact power transfer and system feedback (Figure 6.2-1).

Figure 6.2-1: Closed Loop Cable Motor System

To address the desire to use a micro-controller as the general interface for the system, the team turned to the electronics industry and found the Arduino family of controllers (Figure 6.2-2). Given the large support of the open source community and ease of use inherent to the Arduino platform, it was a sensible choice. After developing advanced enough prototypes we plan on taking out the ATmega328P chip and using that on its own on a custom PCB board to slim down the electronics.

Figure 6.2-2: Arduino

The need of a DC motor to transfer power to the tiller is driven by the force and speed required to move the tiller in an appropriate manner for sailing. Taking into consideration the batteries available on the market, the current and voltage limits of many of the generic control chips available the team thought it best to use a 12 Volt system, drawing 5 for the Arduino and powering the entire system with a single battery.

Understanding that motors are inherently a radial motion device we needed to devise a method of transforming that motion into a linear motion, and using belt and track is the option we decided to pursue. It is a simple solution so there is not much that can wear out over time but it will still get the job done.

To accomplish the task of holding the position of the tiller and rudder constant once the desired turn angle has been achieved, our team has decided to let the servo actively hold the angle in place. This should not use excessive amounts of battery power and it would remove an unnecessary braking component from the motor compartment. Other options were explored due to worries about the abilities of the servo motor we will be using and these are expanded upon in additional information document.

Figure 6.2-3: Sip-and-puff current usage to control power chair steering

Understanding the concept of universal design, the team strove to consider the limited range of motion some of the campers may have. The design of the interface should be spaced for a range of motion similar to the range of motion required for the use of a power-chair, which are used by many of the campers. Having a joystick or sip and puff (see figure 6.2-3) with a space for system feedback nearby is the current solution pursued by the team.

Overriding the adaptive control system should be intuitive, quick, and should not interrupt the function of the system tracking and calibration. Therefore we have decided to have the override mechanism be a separation between tiller and pin (the pin is the connector between the belt and tiller). This way the steering system is changed minimally when the override is used and the counselor has very easy access to the override.

The tiller control system will function, according to the diagram below. Power is supplied to the system from some source (12V 9AH Deep Cycle Marine Battery), with the micro-controller at the center, taking input from the user and the system, and providing feedback to the user. As discussed previously, the micro-controller of choice is the Arduino. Power transfer is accomplished using a belt and track system. This system will provide physical control over the tiller while it is engaged by having the servo rotate a pulley, which pulls on the belt, which moves the pin, which then acts on the tiller. (Figure 6.2-4).

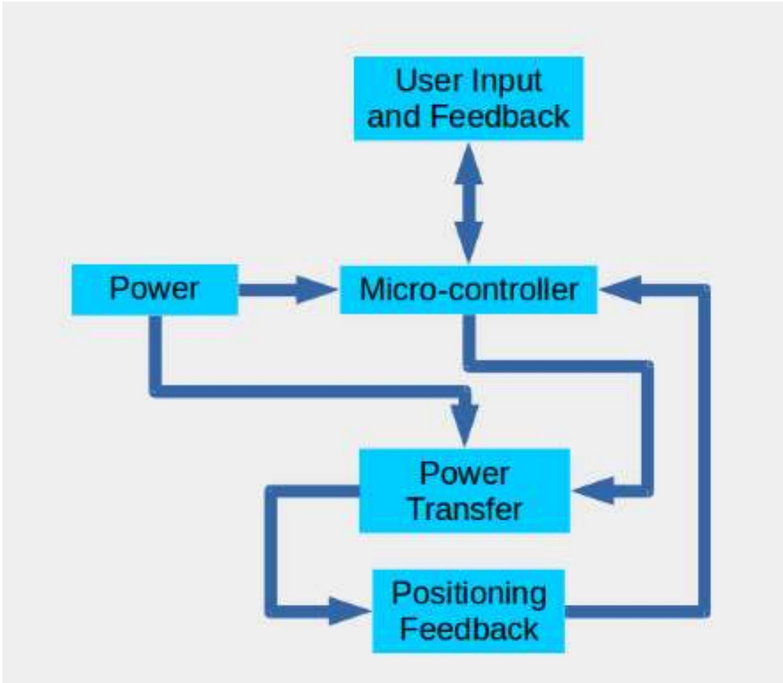


Figure 6.2-4: System diagram

6.2.3 Servo Function

Below is the introduction of the servo we are using. We found a lot of useful information online. Following is the link to the website where we found everything we need about the servo's pulse width modulation. https://www.servocity.com/html/how_do_servos_work_.html#.VXh80kZ8z40

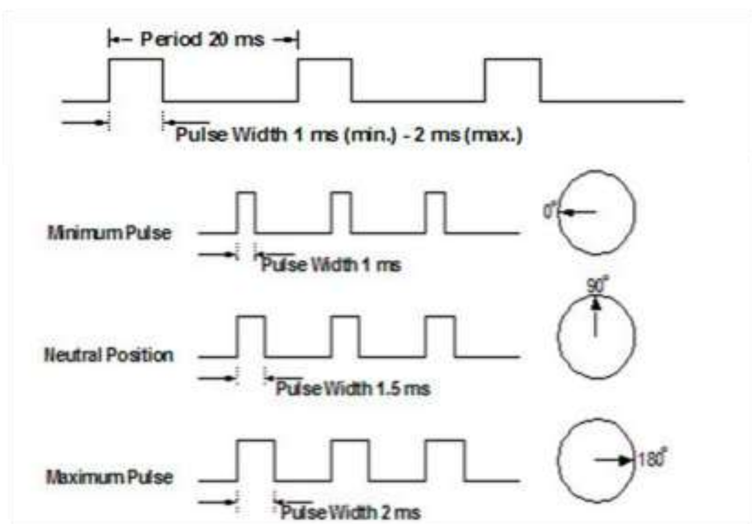


Figure 6.2-5: Servo Pulse cycle

6.2.4 Microprocessor Coding

We have tested different functions separately and we have tested the code to its entirety. The program is functional.

- This program can output the PWM signal for the sailboat servo. There are five different positions that could be controlled with a joystick as well as a sip 'n puff.
- This program has implemented beeper function that could send out indications when the board is powered. It could also accept the voltage input in analogread pin and act as a low battery warning.
- This program can display rudder positions to LED display box.

More details could be found in the program comments.

The program could be found in the semester document.

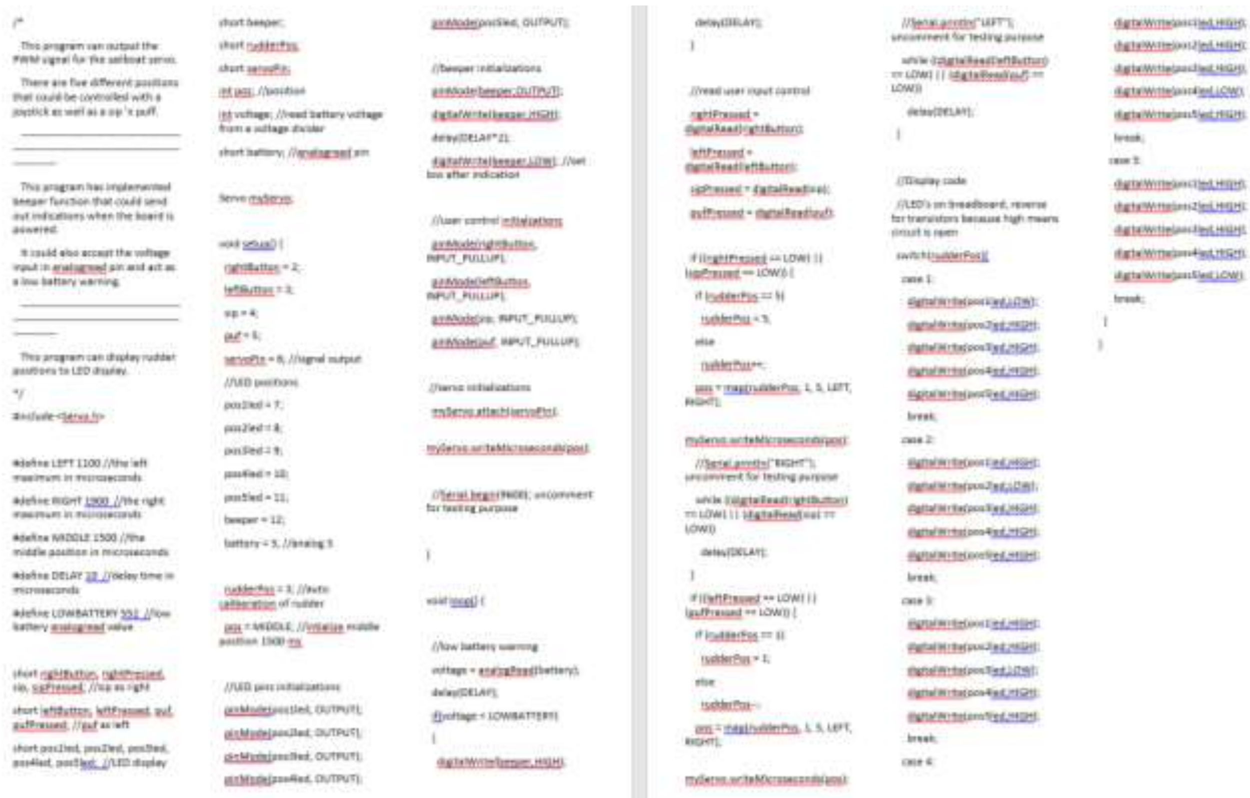


Figure 6.2-6: Code for microprocessor -- Latest Version

```
// PWM code to generate 20 msec/50 Hz pulse
// Duty cycle to control needs to vary from 1 msec to 2 msec
// Modified from code found online (will find source) by CBZ

#include <Servo.h>

Servo myservo;

int duty; //duty cycle in microseconds
int v;

void setup()
{
 duty = 1500; //midpoint value
 v = 0; // initialize number value for input
 myservo.attach(10);
 myservo.writeMicroseconds(duty); // set servo to mid-point

 //Turn the Serial Protocol ON
 Serial.begin(9600);
}

void loop() {

 Serial.print("Duty cycle =");
 Serial.print(duty);

 if ( Serial.available()) {
  char ch = Serial.read();
```

```
 if ( Serial.available()) {
  char ch = Serial.read();

  switch(ch) {
   case '0'...'9':
    v = v * 10 + ch - '0';
    Serial.print("V =");
    Serial.print(v);
    break;
   case 's':
    duty = v;
    myservo.writeMicroseconds(duty); // set servo to mid-point
    v = 0;
    break;
   case 'd':
    myservo.detach();
    break;
   case 'a':
    myservo.attach(9);
    break;
  }
 }
}
```

Figure 6.2-7: Code for microprocessor -- Order Version by Carla

6.2.5 Detailed Design of Interface

The interface we are creating is needed because the user won't be able to look back. In a normal sailboat, the user would look back in order to see the angle of the rudder so they can predict where the boat is going. To compensate for this we need to include rudder angle in the design. In order to achieve this goal our team has decided to use a LED panel with the rudder displayed as several different angles. When the rudder is at a particular angle, say 30^{o}, the corresponding LED will light up of the display that is in line with the image of the rudder at 30^{o}. Our final display will show a full 130^{o}, however not just the 75^{o} shown in figure 6.2-8.

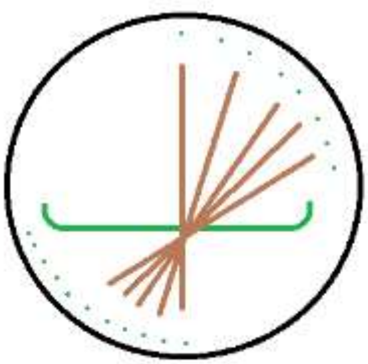


Figure 6.2-7: Example feedback screen of rudder and tiller position

Figure 6.2-8: Concept for our display created in Photoshop

Carter created several possible set ups to use for the interface. They all shared the same idea of showing the rudder angle. Some varied in how specific they were in showing the angle. Carla got us in contact with the Battle Ground Middle School so we could work with kids with disabilities in order to test our designs. The kids and the staff there were incredibly helpful. It showed that just having the rudder angle alone would be too confusing for the kids. It would be better if we show the boat direction to the kids so that it's easier to interpret. However, in order to making this a true sailing experience we still need the rudder angle. So we decided on a combination of the two. There is already a design for it which you can see in figure 6.2-9. It was also recommended that we use picture instead of words to portray what has is being displayed. Julie, a teacher at Battle Ground, said that of the students we worked with only one would be able to fully understand the words "rudder angle" and "direction" and how the related to what they were doing. With all the information we have collected we have started to design a prototype of the interface that future semesters can continue to work on.

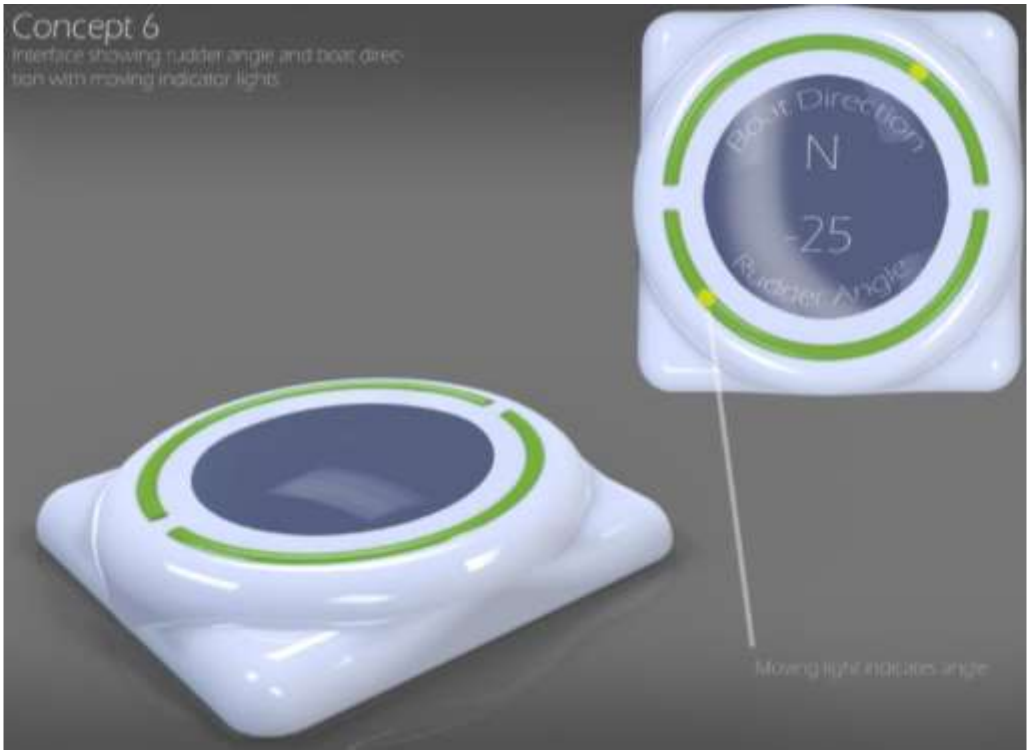


Figure 6.2-9: Final Concept for the interface. It shows both the boat direction and the rudder angle.

6.2.6 Detailed Design of User Control

Observing the campers using devices with which they are already familiar was a great help in the team's decision on how to interface with the user. A seeming majority of the campers were already familiar with a panel mounted joystick and screen interface, so we decided to follow that design. Buttons, such as the ones that would be used in an arcade setting were considered, but for campers with limited dexterity, we thought it may be easier for them to use a joystick, which many campers are already used to. However, for the campers at Champ Camp, we thought a sip 'n' puff method needs to be included as well.

As of right now we are still exploring ideas for how to mount the joystick. Our current idea for mounting the sip 'n' puff is to find a way to strap it to the campers life vest. This will allow the sip 'n' puff to move with the camper's body and keep it from falling out of their mouth. If we were to choose this method we would make our own mount that could be used on multiple life jackets. We created a design matrix for mounting the sip 'n' puff looking at the mounting it to the boat, using Velcro to attach it to the lifejacket, clipping it to the life jacket, and mounting it to the chair (Table 6.2-1). This helped us decide that mounting the sip 'n' puff to the users chest would be the best option. It will allow much easier access for the user and lower the chance that the straw would fall out of the camper's mouth.

Specifications	Weight	Mounted to the boat w/ clamp	Score	Mount to chest with Velcro	Score	Mount to chest with clips on lifejacket	Score	Mount to chair with clamp	Score
Security to stay in user's mouth	4	1	4	5	20	5	20	3	12
Safety for user	5	3	15	5	25	4	20	3	15
Stability to user	3	5	15	3	9	3	9	4	12
Cost	1	5	5	4	4	4	4	5	5
Ease of set up	2	3	6	5	10	5	10	3	6
Sum			45		68		63		50

Table 6.2-1: Design matrix for mounting the sip 'n' puff

In order to increase the flexibility of the set up even further we decided to keep the main control and straw in the motor box and connect a long tube that will run to user. The sensors for the sip 'n' puff only needs a small amount of change in of pressure in order to triggered so we aren't worried about the extra tubbing causing problems with the controls. The tube will have to be thin and flexible and will be mounted with Velcro as was determined early.

As for the joystick, we haven't found any methods that were are sure would be good. An option left form the previous semesters in to mount it on a GPS holder (Figure 6.2-11). This design isn't bad but a dilemma for this mount, and all ideas we have, is that we are unsure where we want to mount it.

Figure 6.2-10: Picture of a preexisting life jacket mounting *Figure 6.2-11: GPS holder possible holder for joystick*

We are considering using a flexible arm in order to make the mount more versatile. We would want the assembly to be easily removable when not in use so were are looking at temporary mounts. A leading idea is a tripod with flexible arms, similar to what is in figure 6.2-12. This would make it easier to attach to any surface on the boat. We are also consider a pivot arm mount. It is similar to the mounts used for mounting some plasma TVs (Figure 6.2-13). This will be much more secure but less flexible. We are still working on creating a housing for the joystick. Once we have that finished it will make it much easier to choose a mount.


Figure 6.2-12: Flexible arm tripod mount


Figure 6.2-13: Swinging arm mount used for TVs.

Both methods of user input will be interchangeable using the same type of male connectors which plug into the casing, connecting them to digital input pins on the Arduino board. The current intention is to allow for multiple modes of operation (continuous and stepping), which may be adjusted to suit the particular user's needs. Also, as the system develops an adjustable input delay will be incorporated.

6.3 MECHANICAL SYSTEM DESIGN

Transferring power to the tiller is the driving concept of the adaptive controls section of the project, and that will be achieved using a servo hooked up to belt and pulley system. Other designs including the use of a linear actuator and various rope and pulley designs were considered and are now listed in the additional information document.

After learning of the geometry of sailing, how the operator interacts with the tiller, and the options for operational modes, we believe our team has arrived at a workable design for our project. We decided to pursue a control system that would fit underneath the tiller and be powered by a servo that is controlled by the commands from an Arduino microprocessor. The power from the servo will pull a belt, which has a pin mounted to it that is connected to the tiller. This system is shown below in figure 6.2-6. A benefit of this design is the use of the underside attachment of the steering system to the tiller allows the manual override to be effective for all positions of the tiller.

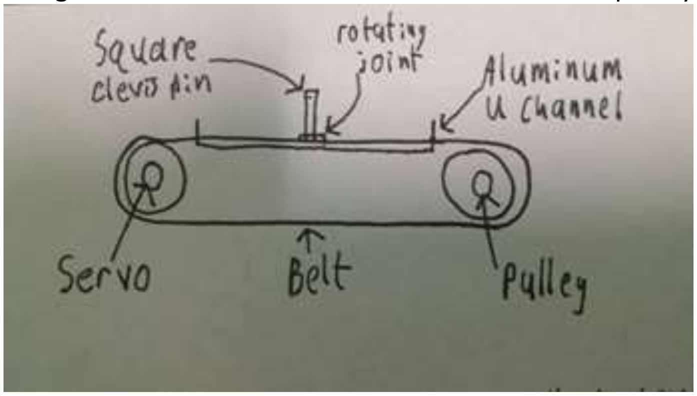


Figure 6.3-1: Steering system design

The next point of the design is the pin. The pin will be a ball pin that fits into the tiller at one end and attaches to the belt on the other end. The location that the pin attaches to the belt will be a plate so that the pin can remain vertical as it goes along the track overtime.

At the moment, our plan for the tiller is to make it out a wooden U channel. In addition, we will cut two grooves along the inside edges of the U channel so that the balls of the ball pin will fit securely in the channel. We will also need an adapter part between the U channel and the top of the rudder where the tiller and rudder meet. This is because our U channel will be too wide to fit inside the metal slot that holds the current tiller. This is illustrated in figure 6.3-2. We plan to get this issue resolved before the end of the semester.

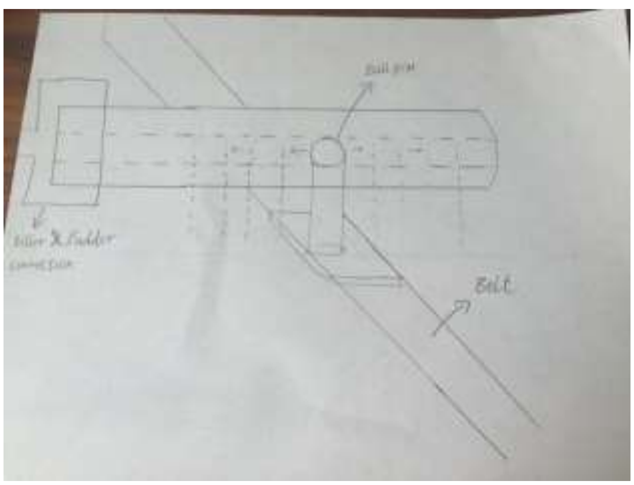


Figure 6.3-2: New tiller design

We decided that sufficient speed of motion would be if we could move from 50^{o} to 130^{o} in less than 5 seconds. We are not too concerned about the rudder moving too slowly because if the rudder moves too quickly then some of the campers may have difficulty attaining the exact rudder position they wish to achieve. We also decided that a sufficient range of motion would be from 50^{o} to 130^{o}, that way campers may achieve a sharp turn to either side. Previous teams work has assured us that the servo will be able to apply sufficient torque both move the tiller and prevent it from changing positions while the boat is turning (see additional information document). Based upon these criteria, our decision to use the servo as our method of powering the steering system is supported, as the servo should be able to match these needs without a problem.

Our current design for the manual override is relatively simple. Because the pin that connects the belt and the tiller is simply a clevis pin, the counselor will be able to simply pull the tiller off of the pin and immediately have control over the tiller.

6.3.1 Motor Casing Design

Figure 6.3-3: Prototype of the motor case

Xie worked with Amy to construct the prototype of the motor case. The dimension of the motor case is 30"*10.5"*6.5". The prototype has been constructed by using paperboard. Motor case was changed from trapezoid shape to rectangular shape based on our analysis. The advantages of using rectangular shape instead of trapezoid shape are

1. Meet the 6-8 inch design standard from rudder-tiller connection to pin when it is at middle of the track.
2. Easier to construct on AutoCAD
3. Take less time to build the actual case in machine shop

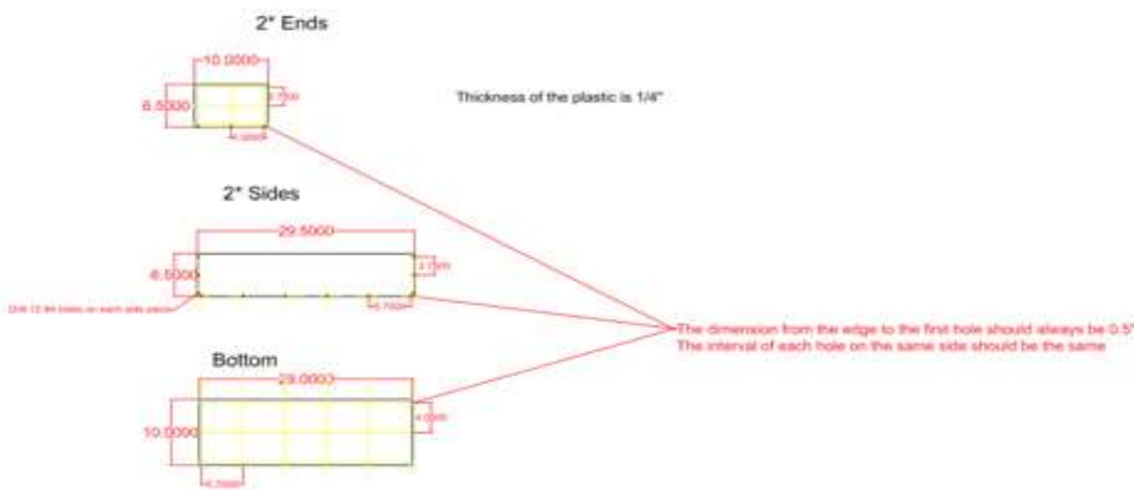


Figure 6.3-4: Dimension of motor case

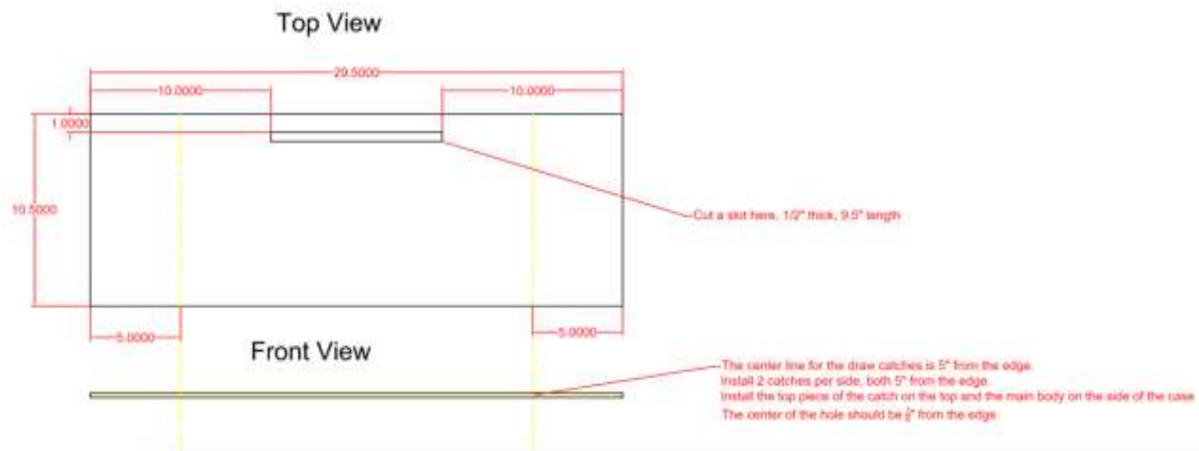


Figure 6.3-5: Dimension of the top part of the case

This is the dimension of the lid. The slot is 9.5" long. There are four latches in total, for two on each side. Latches are 5" from the edge of the lid.

Our team cut down the wood divider by using machine saw and un-drilled the screws from the original board. After that, new location of holes was re-drilled and the gear system was re-attached to the wood divider. The dimension of the divider is (29.5" *¾"*6.25")

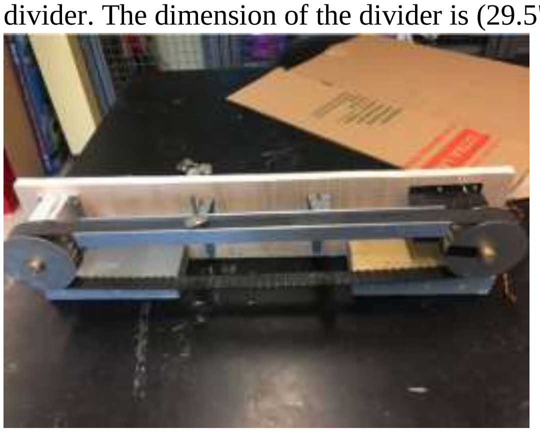


Figure 6.3-6: Motor to move the rudder

Figures 6.3-4, 5, 6 show our current design for the motor casing. This fulfills the requirement that there needs to be something covering the whole motor design for the safety of the campers and to make sure nothing is damaged or gets too wet.

To fit the case into the back of the boat, we decide to make the outside dimension to be 29.5" * 10"*6.5"(L*W*H). We cut the height from 8.5" to 6.5" because we decided to add 2" thick foam under the case. The reason to do that is because the case cannot be smaller since our gear system is 29". However, this dimension was still larger than the boat's back dimension. So we decided to add shorter foam under the case so we could avoid the raise inside the boat. And we decided to make the bottom and ends of the case inside. So it would maximize the water-resistant capability. What's more, it would also benefit our fabrication since sides would only have threaded holes and bottom would only have drilling holes. (Which means, only ends have both threaded and drilling holes)

Figure

Figure 6.3-7: Top view of our motor casing design

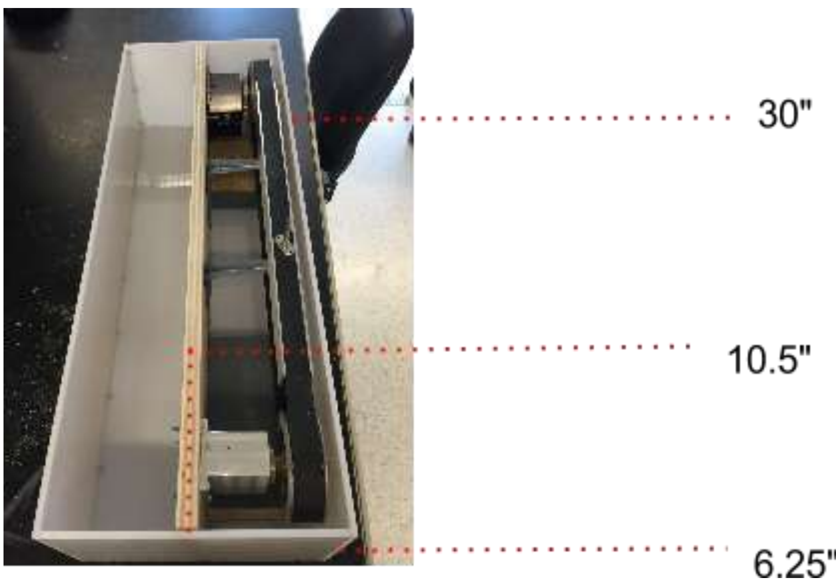


Figure 6.3-8: Angled top view of our motor casing design

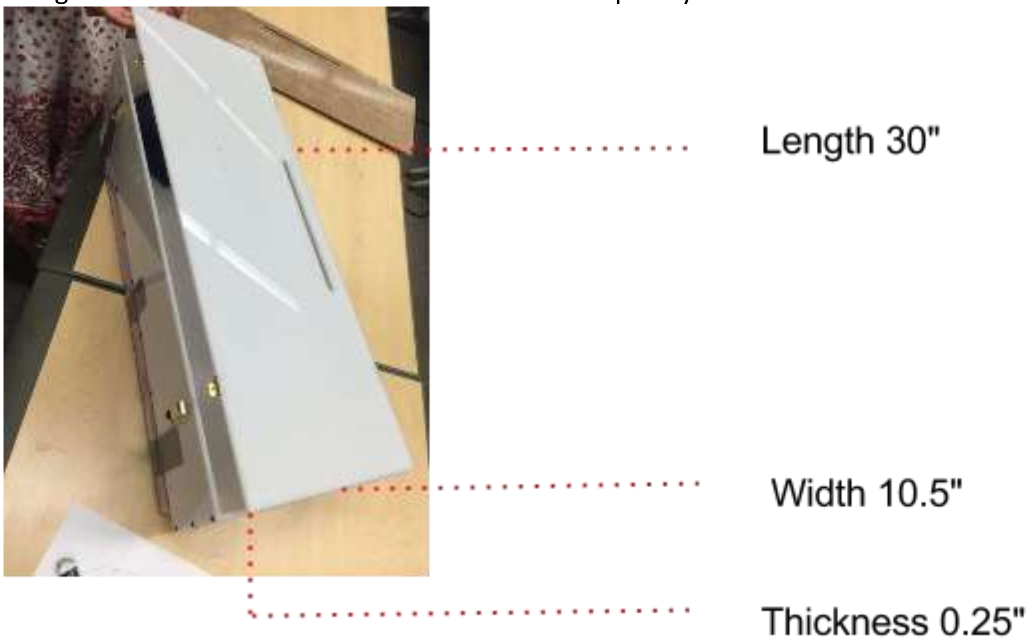


Figure 6.3-9: Dimension of the lid

Four latches has been added on the motor case. The lid fits pretty well on the motor case when four latches were closed.

Professor Roberts has started working on the final design for the internal mounting of the box. He's working with an experienced machinists in order to have all the parts created efficiently.

6.3.2 Goals for Motor Casing

1. Waterproofing the casing in order to prevent damage to internal components

2. Securely mounted so that box won't be moved violently which may cause damage to the inside

3. Thermally stable so that the components don't over heat during expected use.

4. Mechanically stable so that the constant change in direction of the servos don't cause the box to fall apart.

6.4 Seating

6.4.1 Specifications

Over the course of the last few semesters, the previous teams put together the following list of the most important qualities that must be met for the seating in the sailboat.

Requirements	Sources
• Provide trunk support and cushioning	• Current seats in canoe: hard back seats and bean bags

• Boom clearance o 28" from centerboard to boom o Trough provides additional 7.5" o Desired seat angle - 110˚-130 ˚	• Camper feedback of seat angle at centerboard position
• Room for ventilator	• Champ Camp
• Forward visibility	• Testing seating arrangements while sailing
• Room for at least 1 other counselor in the boat	• Champ Camp

Table 6.4-1: Shows requirements for seating from previous semesters

In addition to the requirements for the camper to have enough room for all of their accommodations, we want to make sure that the seat is durable and somewhat water resistant as well as cost effective. We also need to make sure that we will be able to fit it into the boat and attach it easily.

Seating Attachment

Based on the previous teams findings these are the criteria that we used in selecting the seating attachment for the sailboat.

Requirements	Sources or Rational
• Removable	• Counselors may want to remove the seat when the camper is using only the beanbag
• Easy to take on and off boat	• It is important to avoid further complicating the counselors job
• Easily maintained	• We want to avoid creating additional costs or issues for the camp
• Won't damage boat	• If possible, we want to minimize modification to the boat and make all attachments removable
• Cost effective	• If something happens to the attachment, we do not want the camp to have to pay excessive amounts to have it replaced
• Waterproof or relatively waterproof	• Won't become loose or unattached due to water damage

Table 6.4-2: Shows our new requirements

6.4.2 Findings and Recommendations

The camper seating will have three options in the boat: back, center and front. The first placement of seating is the area to the side of the centerboard on the centerboard seating (Figure 6.4-1) (Center one). The centerboard seating provides an easy method of securement if needed and is already stabilized within the boat, making it a good attachment point for a seat.

Figure 6.4-1: Position of Side Centerboard Area Seating

The second placement of seating is in the trough area of the boat (Figure 6.3-2). We would utilize a beanbag, like the one Champ Camp has but smaller, to seat campers in this section of the boat to provide molded cushioning. The camper would be sitting forward of the tiller and outrigger bar, which creates empty space for the camper to place his/her ventilator.

Figure 6.4-2: Position of Trough Seating

The third position will be in the front of the boat. This seat can provide campers a broader view of the sailboat. So it would be more comfortable for campers to control the sailboat. We also plan to add cushions in the front to give more comfortable experience for campers.

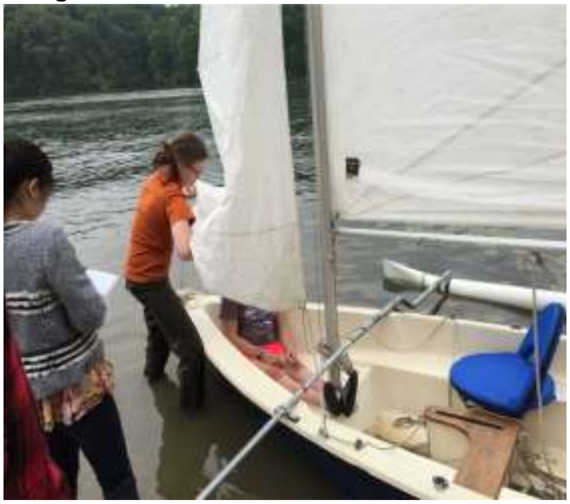


Figure 6.4-3: Location of third position

6.4.3 Detailed Design

The design for the centerboard area seating requires a seat back against which the camper can rest. Ideas for this include: crazy creek chair (Figure 6.4-4), ratcheting seat (Figure 6.4-5), or clip-on stadium seat (Figure 6.4-6).

Figure 6.4-4: Crazy creek seat http://www.amazon.com/Crazy-Creek-Original-Chair-Royal/dp/B0000D8HH0/ref=sr_1_8?s=sporting-goods&ie=UTF8&qid=1406143475&sr=1-8&keywords=crazy+creek+chair

Figure 6.4-5: Ratcheting seat http://www.walmart.com/ip/Stansport-Portable-and-Adjustable-Chair-Blue/16224731

Figure 6.4-6: Clip-on stadium seat http://www.walmart.com/ip/Stansport-Folding-Stadium-Seat-with-Arms-Green/10154038?action=product_interest&action_type=title&placement_id=irs_bottom&strategy=PWVAV&visitor_id=54465944738&category=0%3A4125%3A546956%3A4128%3A1080625%3A1080644&client_guid=6bb321b8-adea-4cdd-850b-48f1b9df2c30&customer_id_enc=1cf4514116c7b113d588aeee9cd67951&config_id=0&parent_item_id=16224731&guid=f5005578-2675-42ad-bf94-dee7240454c1&bucket_id=irsbucketdefault&findingMethod=p13n

If the seat does not provide adequate seat cushioning, cushioning will to be added to the plank. An important consideration for the cushioning is the additional height caused by increased cushioning. Thicker cushioning will increase the camper's height and decrease the amount of space for boom clearance. When the boom swings across the boat, the camper must be low enough that he/she doesn't get hit in the head by the boom.

Fall 2014 semester tested this seating arrangement with campers to collect feedback on the comfort and accessibility of the position as well as the appropriate angles and seat thickness. They found the best seat angle to be a range between 110˚-130˚ in order to provide boom clearance while still maintaining a comfortable reclining angle and forward visibility (Figure 6.4-7). During this testing, the camper was sitting on a PFD (Personal Floatation Device) approximately 2'' thick. In order to accommodate taller campers who prefer to sit more upright, the bottom cushioning should not be as thick as the PFD.

Figure 6.4-7: Dom testing out seating in the centerboard area position

Dom, the camper shown in Figure 6.4-7, is about 5'8'' and had to recline to an angle of about 120˚ in order to clear the boom. He was more comfortable leaning back to 130˚ but if he was not comfortable leaning this far back, then he would not have fit in this seat.

We believe that the cushioning should be between ½'' to 1'' to provide enough comfort but maximize height space. Cushioning that we considered if we chose a seat design without cushioning included placing foam over the entire centerboard plank and covering the foam with vinyl, an example of foam would be cutting a yoga mat to the correct shape, or using outdoor carpeting to cover the plank.

The only chair that we found available at stores was the canoe seat. We were initially concerned that the adjustable straps would not provide enough support at a reclined angle of 130˚ but found that the chair remained supportive at this angle. This concern also applied to the crazy creek chair and the stadium seat because they also have adjustable straps. The canoe seat, ratcheting seat and stadium seat have a metal frame for support while the crazy creek seat does not. Since the crazy creek seat does not have a metal frame, it may not be as supportive as the canoe seat at greater angles.

The trough area seating will use a smaller beanbag like the ones that Champ Camp uses for their campers in the canoes currently. The camper will have to sit forward of the tiller so that the tiller can move freely to steer the boat. After placing the canoe outriggers on the boat, the fall 2014 team realized that the stern bar would provide a natural barrier from the tiller and control mechanics to the camper's seating (figure 6.4-8, Note - outrigger bar not pictured). The primary counselor must be seated in the stern of the boat in order to control the sail and, if necessary, the tiller. This puts the counselor and the camper in close proximity and may be uncomfortable for the camper. Since the camper must sit out of the way of the tiller, the camper's leg room is occupied by the centerboard plank, which forces the camper to put his/her legs on (Figure 6.4-8) or under (figure 6.4-9) the plank. If the centerboard area seating is collapsible, the camper can rest his/her legs on top of the chair, which will provide cushioning, and if the seat back is removable then plank cushioning will likely be present to provide comfort. If there is no cushioning from the centerboard area seat, the counselors can place a PFD on the plank to provide leg cushioning.

When considering camper seating options, it is important to note the weight balance of the boat. The camper will likely be in a permanent seat and the counselors will be in a semi-permanent seat as there is not much room to move around. If a motor is used on the sailboat, it will be mounted to the left side of the stern when facing the bow. Due to this, we recommended seating the camper on the right side of the boat.

Figure 6.4-8: Trough seating with counselor sitting on boat seat and camper in trough

Figure 6.4-9: Leg room below plank for trough camper seating

Specifications	Weight	Crazy Creek	Weighted Score	Ratcheting Seat	Weighted score	Stadium Seat	Weighted Score
Cost	1	2	2	3	3	3	3
Durability	4	2	8	2	8	3	12
Weight	2	2	4	2	4	1	2
Accommodating	6	2	12	2	12	3	18
Comfort	3	3	9	4	12	2	6
Ability to Recline	5	3	15	3	15	0	0
Sum			50		54		41

Table 6.4-3: Decision matrix for top three seating options

Seating Attachment

Some ideas the fall semester came up with were Velcro, steel Velcro, super glue, nails, clip on mechanisms, a slide and lock in part, or suction cups. We narrowed the options down to heavy duty Velcro, glue, clip-on mechanisms, and the slide and lock in part.

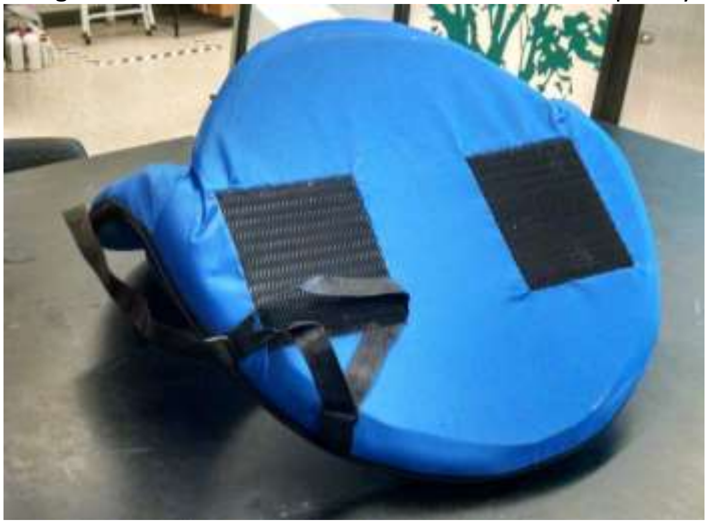


Figure 6.4-10: Velcro on the bottom of the ratcheting chair

However, after further consideration, we decided that the slide and lock option was too much modification to the boat, so we dropped that option from the list. Furthermore, when we considered how we might use clip on mechanisms to secure our chosen seat (the ratcheting chair), we found that there wasn't any way to securely fasten the chair without the clamp being in the way of the camper, so this idea was dropped as well. This left us with glue and Velcro as our remaining options. Velcro was quickly decided upon due the option of removing the chair when it is not needed whereas glue would be too permanent of an option. Our chair with the Velcro added is pictured above in figure 6.4-10.

This still left us with a few problems to resolve. We had to figure out how to attach the Velcro to the centerboard, how to attach the Velcro to the bottom of the chair, and how to make sure that the two sides of Velcro linked together thoroughly. In the end, we decided just to use the adhesive on the back of the Velcro to stick the Velcro to the centerboard and sewed the Velcro to the chair with an extra fabric backing to ensure that the Velcro would not tear the bottom fabric of the chair. Furthermore, we cut out a piece of polycarbonate that fits inside of the blue fabric casing of the chair. This makes it easy to press down on the top of the seat of the chair and join the two pieces of Velcro.

Further Security of the Seat

Upon examining the set up from the semester before us, we decided that just Velcro wouldn't be reliable enough. While it would hold the chair in place, it is still possible to accidently unfasten it. To help solve this we looked into several different options. They are all listed in the matrix below.

Specifications	Weight	Lashing Straps	Score	Swivel mount	Score	Ratcheting Straps	Score	Swivel w/ lock	Score
Cost	1	5	1	5	5	4	4	1	1
Durability	2	4	8	5	10	2	4	4	18
Security	6	3	18	3	18	4	24	5	30
Removability	4	5	20	1	4	5	20	1	4

Ease of Set up	5	4	20	2	10	3	15	1	5
Accessibility	3	5	15	2	6	4	12	3	9
Sum			82		53		79		67

Table 6.4-4: Decision matrix for top four seating securing options

From this we determined that the lashing straps would be the best option. They are very secure and wouldn't damage the boat. Another big plus is that it would still allow the seat to be removed unlike the swivel mounts. The straps are also still easy to use and are tightened by hand allowing the straps to be tight but not so tight that they would damage the boat like the ratchetting straps would

6.4.4 Goals for this Semester

1. Increase security of seat to ensure safety of camper in it.

6.5 Safety

6.5.1 Specifications

The safety specification outlined by both Bradford Woods and the previous team was that the boat could not capsize. Throughout the course of our project we identified additional requirements for safety: stability on the land and stability on the water. Once our team identified outriggers to be appropriate technology for safety, we identified further specifications: sufficient turning radius, space for manual paddling and transportable. The additional stability required for sailing is to prevent the boat from keeling too far and making the camper feel uncomfortable. We discovered this requirement through observing inexperienced sailors and observing their reactions to drastic tilting of the boat, especially during turns. The additional stability on land is required so the campers can enter and exit the sailboat without it rocking. This would allow campers to enter and exit the boat with limited assistance.

Requirements	**Sources**
• Prohibit capsizing	• Champ Camp
• Keep boat stable on land during loading	• Sailing test: Unstable entry on land
• Limit keeling of boat on water • Sufficient turning radius	• Sailing test: Boat keels too far
• Seasonal and transportable	• Camp Riley Staff
• Space for manual paddling	• Counselors
• Low battery warning • Circuit working indication	• Beeper
• Circuit damage protection	• Protection fuse

6.5.2 Findings and Recommendations

After taking into consideration all of the research and testing, our team has selected our solutions to fulfill the requirements. To prevent the boat from capsizing and providing sufficient stability while sailing, the team is moving forward with the design using canoe outriggers (figure 6.5-1). We have been asked to use the same outriggers currently used with the canoes at Camp Riley on the sailboat so we do not need to build new outriggers, we only need to build a way to safely secure the outriggers to the sailboat. For this problem, we have decided to use a modified hitch design to mount the outriggers to the boat, as illustrated by the decision matrix below. (Our decision is labeled “hitch system” in the matrix.) In order to do this, we decided to fabricate our own aluminum brackets through the AFL so that they will be of the exact right size and gauge to securely hold the outriggers to the boat without any risk of snapping.

Figure 6.5-1: Prototype outrigger testing while sailing

To stabilize the boat on land, a pool noodle should be placed on either side of the underside of the hull as shown in figure 6.5-2. This provides sufficient stability for campers to enter and exit the boat on land. Exact implementation of the pool noodles is outlined in the detailed design section.

Figure 6.5-2: Pool noodle wedged between the hull of the boat and the sand. Boat currently resting half on land, half on water for easy push from dock.

6.5.3 Detailed Design

Outriggers

Below in figure 6.5-3 are the outriggers we will be using on the sailboat to prevent it from capsizing. The dimensions of these outriggers are described in Table 6.5-1.

Figure 6.5-3: Canoe outrigger attached to the canoe. It is currently sitting upside down on a rack. The outriggers are not completely circular, but rather more of a petal shape on the edges.

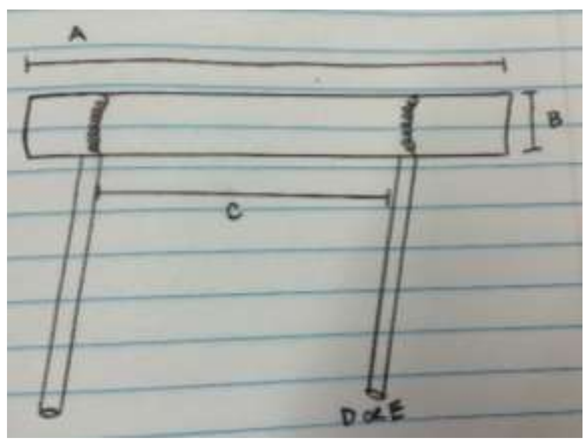
Object	**Parameter**	**Dimension (in)**	**Diagram**	
Pontoon	Length	118.00	A	
Pontoon	Diameter	7.00	B	
Metal bar	Distance from canoe	36.00		
Metal bar	Distance from one metal bar to the other	70.00	C	
Metal bar	Outer diameter of smaller pole	1.125	D	
Metal bar	Inner diameter of larger pole	1.375	E	
Metal bar	Outer diameter of large pole	1.5	E	

Table 6.5-1: Outrigger Dimensions

We selected two outriggers with different diameter metal bars as the outriggers that we will use for our project. By choosing two different diameters, we can interlock the two ends (figure 6.5-4). After removing the outriggers from the canoes, placed one on either side of the sailboat, and then interlocked them. The pontoons were approximately 40.00” away from the hull of the boat. The front bar will be situated directly in front of the mast and the back bar will be directly in front of the tiller. Information about sailing while the outriggers were on the sailboat in the configuration shown in figure 6.5-4 is in the additional information document.

Figure 6.5-4: Interlocking metal bars of outriggers

Outrigger Attachment

Specification:

- Allows outrigger to be placed and removed easily
- Very secure attachment to outrigger
- Very secure attachment to boat
- Durable
- Relatively inexpensive
- If it fails, how bad will the consequences be
- Safe (will not injure campers)

Solution:

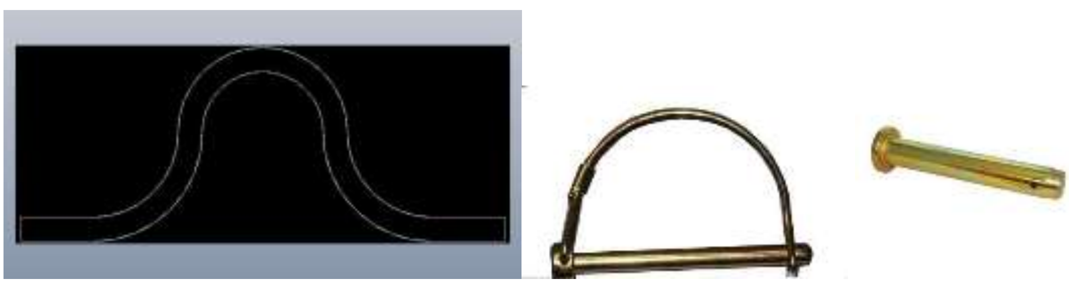


Figure 6.5-5

Figure 6.5-6 Picture of clamp that secures the outrigger

To mount the outriggers to the boat we thought of eight different solutions (the decision matrix is below). The one we picked was a modified hitch system design which we have fabricated through the AFL, with the exception of the pins which we bought from stores. To expand upon the design, we have attached four custom cut aluminum brackets, two larger ones on the starboard side, two smaller brackets on the port side. Each bracket has a D-pin that goes through both the bracket and the outrigger pole. In addition, rubber pads have been placed between the pipe and the fiberglass of the boat to prevent the outrigger pole from inflicting any damage to the fiberglass of the boat. For an illustration of the upper side of the bracket attachment see 6.5-6 above. Last, we made ABS plastic plates that we used as pressure-distributing plates for the underside of the boat lip to ensure that the fiberglass wouldn't crack when we tightened down the bolts. The last feature we will be adding is tying the D pins to the brackets with spider wire so that they cannot be dropped into the water or lost.

Criteria	Weights	Square Bracket	Hitch System	Bike Seat Clamp	Thule Clamp	Double Pole Clamp
Easy to Use	2	3	3	4	5	2
Secure attachment to outrigger	5	2	5	3	4	4
Secure attachment to boat	5	5	5	1	2	3
Durability/ Material	4	3	4	1	4	4
Safety	4	2	3	4	3	2
Fail Safe (Failure Situation)	5	1	4	4	3	3
Price	1	5	5	4	2	4
Totals	--	21	29	21	23	22

	Exhaust Clamp	Fastenal Alum. Clamp	Sign Clamp	Weighted Totals	Square Bracket	Hitch System
	1	4	2		6	6
	3	4	4		10	25
	5	5	2		25	25
	5	5	3		12	16
	3	3.5	3		8	12
	4	4	3		5	20
	5	1	3		5	5
	26	26.5	20		71	109

	Bike Seat Clamp	Thule Clamp	Double Pole Clamp	Exhaust Clamp	Fastenal Alum. Clamp	Sign Clamp
	8	10	4	2	8	4
	15	20	20	15	20	20
	5	10	15	25	25	10
	4	16	16	20	20	12
	16	12	8	12	14	12
	20	15	15	20	20	15
	4	2	4	5	1	3

Table 6.5-2: Decision matrix for deciding outrigger attachment.

On-land Stability

To stabilize the boat on land, Fall 2014 stumbled upon the solution of sticking a pool noodle on either side of the boat, underneath where it begins to slope. This way the pool noodles support the weight of the boat and prevent it from rocking back and forth when people enter from the side. We tested the stability of these pool noodles by asking two campers to get into the boat. The first used all of his upper body strength (no use of his legs) to support all of his weight on the side lip and hoist him up. He commented that he could not feel the boat rock much at all and felt comfortable using it as leverage. The second camper had full mobility, but was unsure how to easily enter the boat. We watched as he stepped one foot in and then grabbed a cable to pull the other side of the body into the boat. We worried that the higher weight distribution would cause the pool noodles to slip or the boat to start leaning, but this was not the case. After working with the boat all morning we checked the placement of the pool noodles and found them in the same secure position as we originally placed them.

While pulling/pushing the boat from the sand to the water the boat slid easily off the pool noodles. We tried pulling the boat while it was completely beached or if the stern end was on the water and found that the second solution worked much better. It did not take as much force, or as many people, to cast off the boat when it was half in the water. Also, the pool noodles still stabilized the boat enough so it didn't sway.

7. Semester Documentation

7.1 Summer 2016

7.1.1 Team Members

Sreyas Mirthipati - Design Lead
-Computer Engineering

Franklin Shiao - Financial Officer
-Computer Engineering

Tong Yao - Archivist
-Electrical Engineering

Mike - Project Partner Liaison
-Mechanical Engineering

Rayane - Webmaster
-Electrical Engineering

7.1.2 GAANT Chart

Figure 7.1-1: The first version of our GAANT chart

Our current GAANT is too large to be displayed here to view [click here.]

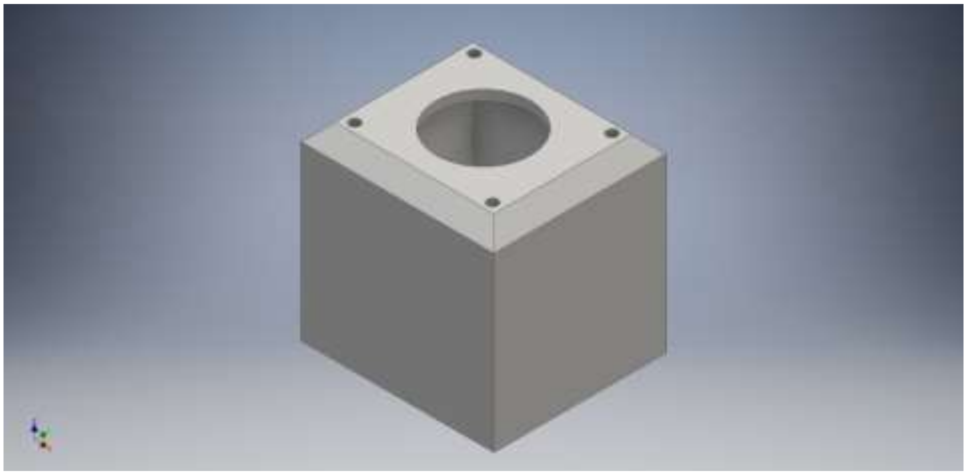
7.1.3 Summary of Semester Progress

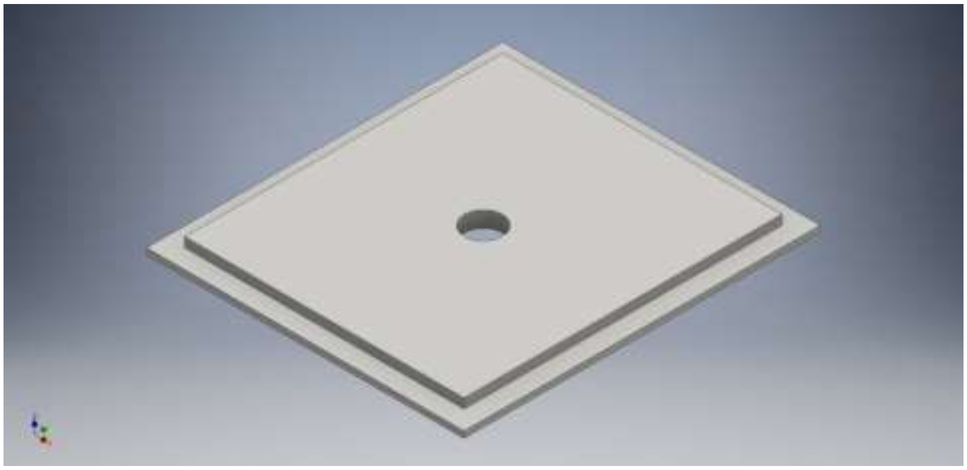
- Designed a new joystick casing
- Completed budget and early versions of our GAANT chart
- Finished and tested the display for user feedback

- Modified the casing to provision for all required ports
- Determined and purchased necessary wires to be used in final product
- Wrote code for all systems to function together
- Functioning prototype of control system electronics with arduino
- EAGLE Design of wiring diagram and Printed circuit board
- Component values, sizing, spacing, and placement.
- Bill of materials of project components and parts

7.1.4 Joystick Modifications

We decided to redesign the previous semester's joystick casing. The reasons are the following: Water-Resistant design, stable, robust and more durable.





The top part is designed to come over the joystick to completely cover it from water splashes. There is sufficient space to accommodate the entire joystick. Once the joystick is in place with the wires attached, the bottom part can be fixed. There need to be a way to attach the wires inside the box so that they cannot be easily ripped off.

The design was completed with Autodesk Inventor 2016, the result of three prototypes. The final design was 3-D printed using ABS material, chosen for its durability and robustness.

The bottom and top parts are attached together using either glue or screws. The whole box can be attached to the sailboat using those same screws or more elaborate ways.

The current joystick may too mechanically resistant. For disabled students, it may be preferable to replace this joystick with a more ergonomic one.

7.1.5 Box Modifications

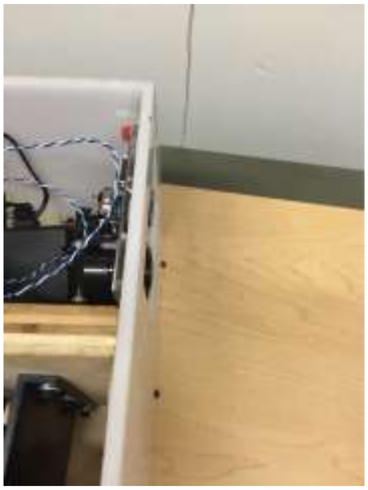
In this summer, we mainly focused on redesign one side of the box which mounts the metal plate on the box board to organize all the cables, beeper and sip n puff. The original board is just like the picture below, it is an irregular shaped rectangle. Although it could fit the metal plate on the box, it is not suitable when we put the wood control panel into the box and multiple components sticks out of the box which create a potential of damage of those components when the user trying to move around the box.

We redesign and manufactured the board of the box to make the location of the hole upper in the right middle of the board so it could fits the wood control panel that is placed inside the box and we even have space to add the wing nut to the metal plate to make it removeable for the user.

We also designed a space that functioning as a washer placed in between the metal plate and the lexan board of the box so that to keep beeper and other components within the box range and prevent from damage.

For the design and manufacture the parts, we first design the CATIA model for the component and sent the material to the AFL lab to manufacture by using the laser cut machine to do all the cutting work. The result is really nice and smooth.

Here is the picture of the final deliverables, it looks perfects and do exactly what we want.



7.1.6 Display

The previous semester's display plans were carried out by our team. Minor corrections had to be made to their design to make the functional display possible. The previous semester hot-glued the 3mm LED's into the display and had them removed for unknown reasons. This resulted in debris that prevented new LED's from being inserted into the slots.


This debris was removed using a screwdriver which had a diameter the same as the LED holes themselves.

Next we designed the display itself. Initially there was a slot for a 9V battery but our design did not make use of this compartment. Instead the power supply for the LED's would be supplied directly from the 9V battery. Each LED can receive no more than 3.3V so by placing three of these LED's in series we could distribute the 9V potential into three 3V potentials. A total of 50 LED's were ordered for the creation of this display and for excess parts. The LED's are 7790 mcd green leds, they are very bright and can easily be seen under the sunlight when lit properly. The ground connection for these LED's is on the top side (where the LED's are further apart) and the input connection is at the bottom (where the LED's are close together.)


These LED's are connected using a cable with 8 connections, 1 for each row of LED's and 1 for the ground connection. There are two excess connections which are not used. The connections are:

Red: -90°
Green: -45°
Blue: 0°
Yellow: 45°

White: 90°

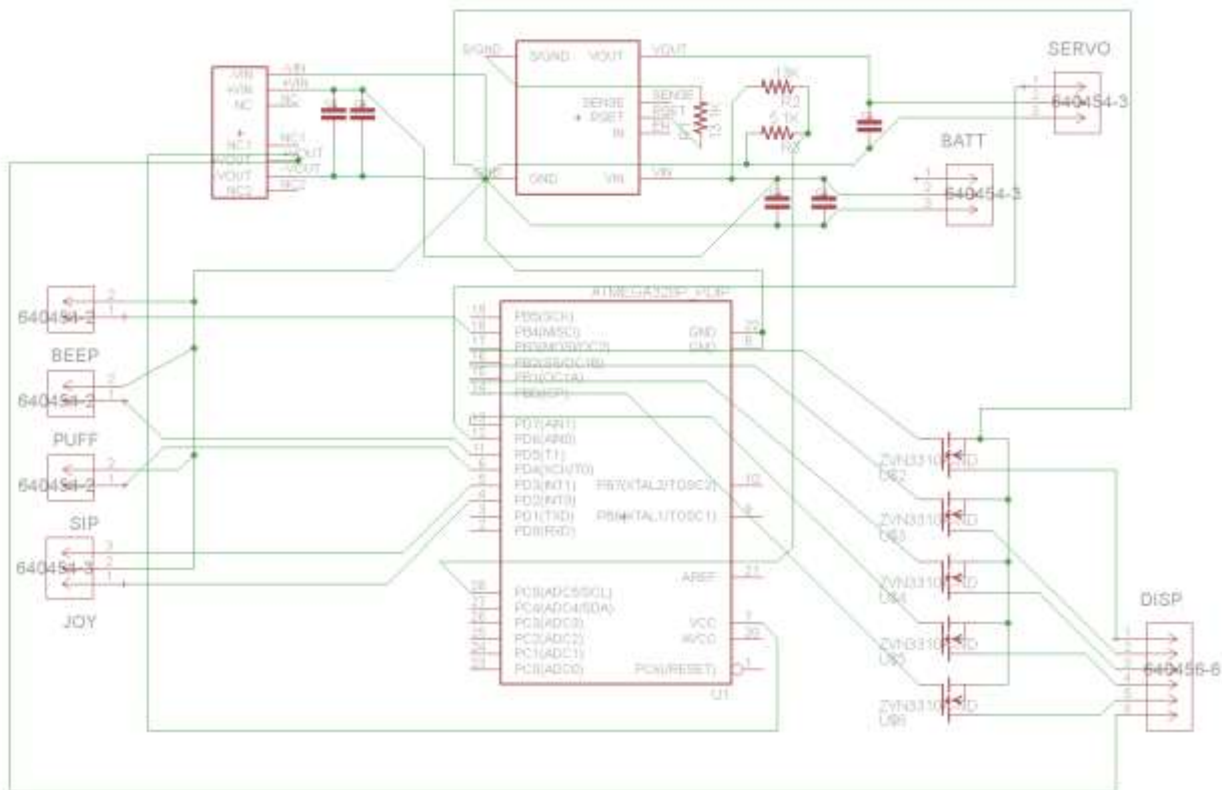
Orange - N/A

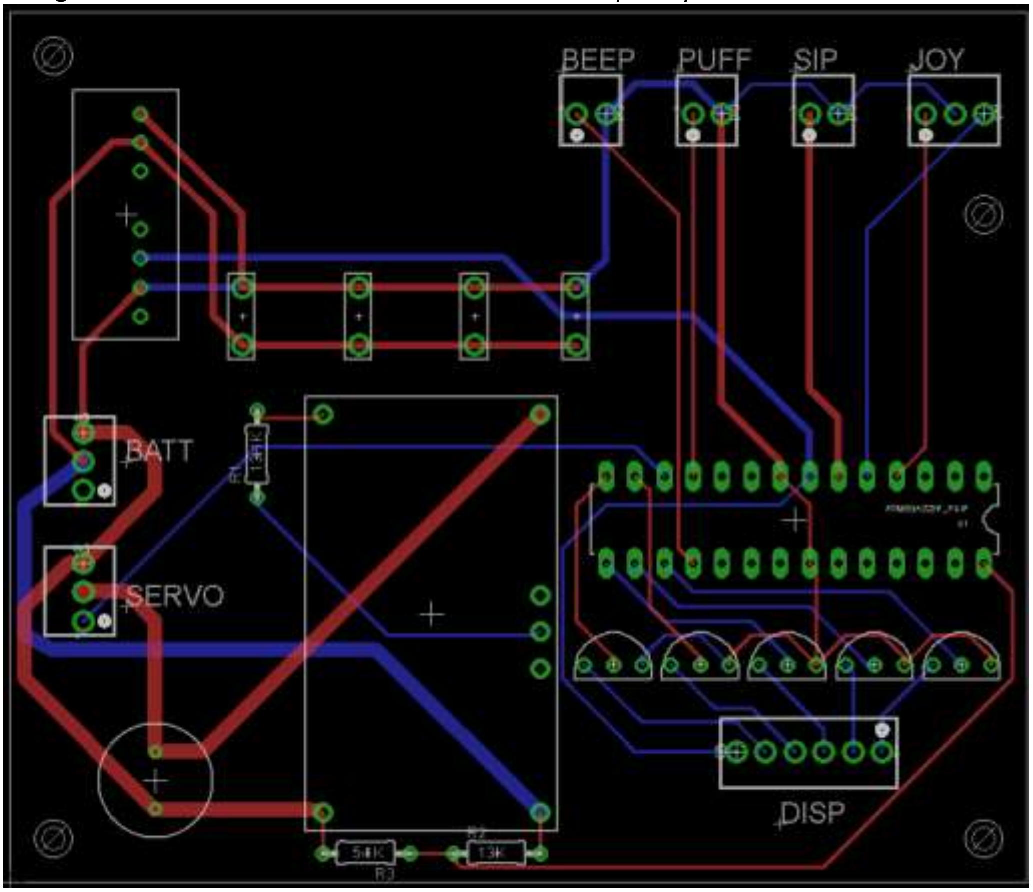
Brown - N/A

Black - +9 volts cable

7.1.7 Circuit Board

We unfortunately were unable to locate the EAGLE files for the existing PCB board design but were able to mimic the physical design that we already had with us. It needed a lot of corrections so that the circuit could actually be complete and the PCB board is ready for manufacture. The designs can be found in the Summer 2016 Semester Documentation folder. More information on setting up the ATmega chip to be able to run in this PCB board on its own can be found in Summer 2016 in Sreyas Mirthipati's notebook in the "External Research" section. Images of both the circuit schematic and PCB board layout are below.





7.1.8 Sip n' Puff

The sip n' puff components were mostly complete at the start of this semester. We were able to improve the system by adding a spit a debris filter and a very light, long, and durable tube to connect the intake to the sip n puff itself.


The yellow tube connects to the small white connector on the top left of the input panel seen above. If the user exhales the control box moves the servo right and if the user inhales the control box moves the servo left.

7.1.9 Battery Mounting

The requirement of battery mounting is the battery should be removeable meanwhile it should tied on the wooden control panel. What we did this semester is to place three right angle connectors on each side of the battery to make it placed on the left side of the box and add an rubber band on the top of the battery.

One side of the rubber band is fixed on the right angle connector and the other side is removeable. This make it super easier for the user to take off battery if they want to recharge. For the safety reason, we have tested the strength of the rubber band-- it is resilient enough that even the boat flipped over, it will sustain the battery from falling into the water.

Here is the picture of our design and it meet exactly what the user need.

7.1.10 Low-battery Warning

For safety reasons, we have implemented a low-battery warning in our code. Because the Arduino analogread pin could accept a input less than 5V, we have also designed a voltage divider. The Arduino functions as a voltmeter and accept voltage from the voltage divider that directly connects to the battery. The resistance we have chosen for the divider are 5.1K ohm and 13K ohm. Connect two resistor in series with the battery, the Arduino takes the voltage across the 5.1K ohm resistor. According to our research with Prof. Robinson, we decided that 9.5V is the low-battery voltage threshold across the battery, and 2.70V detected by the Arduino.

7.1.11 Microprocessor Code

We have tested different functions separately and we have tested the code to its entirety. The program is functional.

- This program can output the PWM signal for the sailboat servo. There are five different positions that could be controlled with a joystick as well as a sip 'n puff.
- This program has implemented beeper function that could send out indications when the board is powered. It could also accept the voltage input in analogread pin and act as a low battery warning.
- This program can display rudder positions to LED display box.

More details could be found in the program comments.

The program could be found in the semester document.

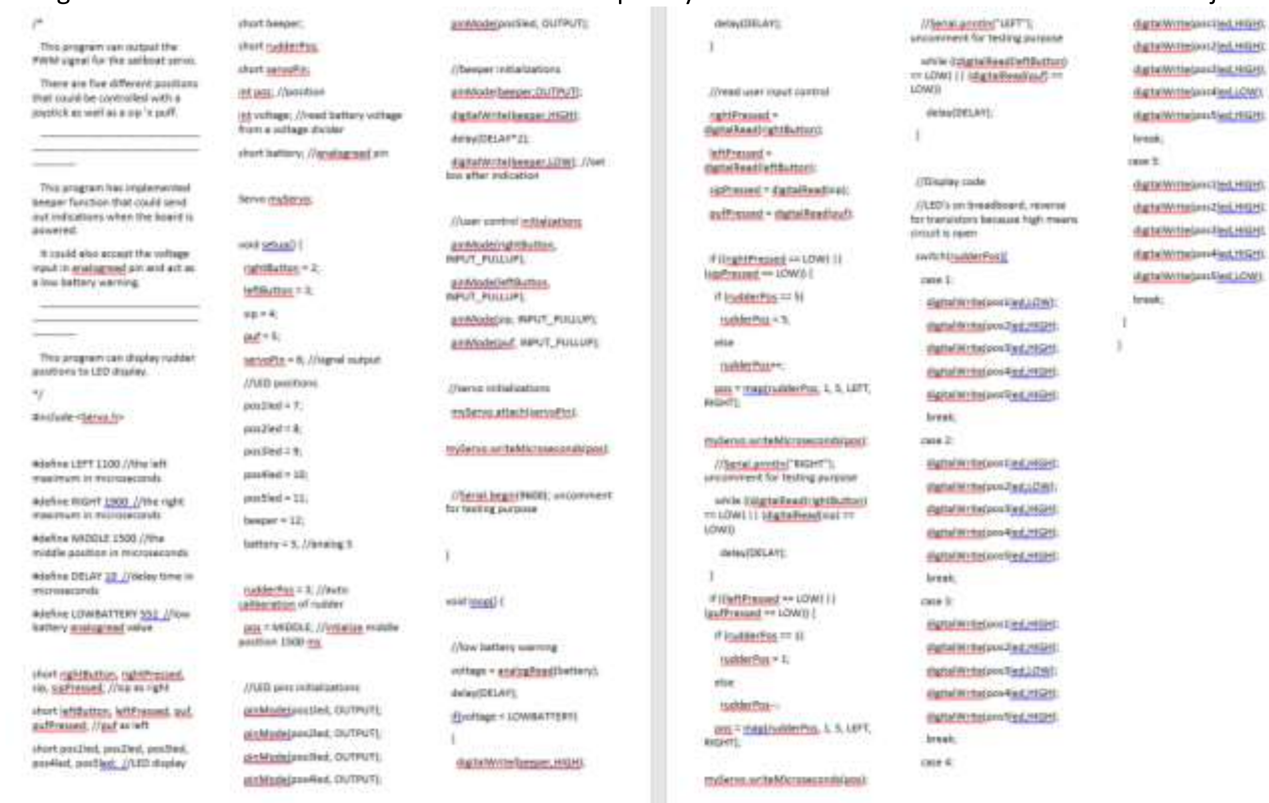


Figure 6.2-6: Code for microprocessor -- Latest Version

7.2 SPRING 2016

7.2.1 TEAM Members

- Azat Imanmussa
  - Electrical and Computer Engineering
- Ruchir Aggarwal
  - Computer Engineering
- Emmy Rawson
  - Biological Engineering
- Logan Letner
  - Electrical and Computer Engineering
- Ao Liu
  - Electrical and Computer Engineering
- Marvyn Patrick Sulindro
  - Mechanical Engineering (FYE)
- Tyler Jonites
  - First-Year Engineering

7.2.2 Summary of Semester Progress(Until now)

- Formulating ideas for mounts for the sip ‘n’ puff and the joystick
- Completed sample budget and early versions of our GAANT chart

- Bill of materials of project components and parts
- Written instructions for battery care and set up a troubleshooting guide but on hold due to battery being finally set up
- Got both 5-volt and 9-volt regulators working
- Formulated ideas for strapping the motor box
- Finished user interface in Solidworks and ordered gooseneck for interface
- Finished joystick case in CATIA
- Finished with joystick assembly

7.2.3 GAANT Chart

Figure 7.2-1: The first version of our GAANT chart

Our current GAANT is too large to be displayed her to view [click here.]

7.2.4 Joystick Improvements

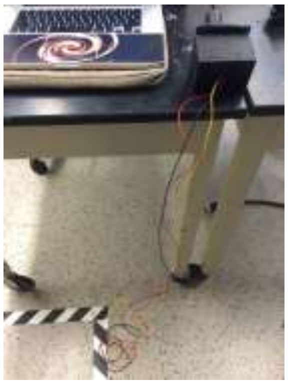
There has been significant changes regarding the joystick aspect of the user input and output in which it was finalized during the end of the semester.

The image on the left is the old design, and the image on the right is the new design.

The joystick itself was ordered online with its original specifications to be a dual axis, four switch joystick. The modifications made for the joystick is of the following:

1. Removal of two switches from four switches
2. Implementation of solid blocks in order to restrict the joystick to one axis - left or right.
3. 3D printed the joystick case according to specific measurements
4. Labeled the directions of the joystick both on top (as shown on the image) as well as the switches
5. Planned the layout for the wiring of the joystick
6. Attached the wiring and soldering them together
7. Attached the case of the joystick with the wires attached
8. Attached plastic tube to encompass the wirings

There are three main wires that protrudes out of the joystick case: A black one, red, and yellow. The black wire is the common wire, red wire is the positive wire for the right switch, and the yellow wire is the positive wire for the left switch. A representation of the wires is shown in the image below.



The wires were connected to the switches with the process of soldering them together as shown as on the image on the right.

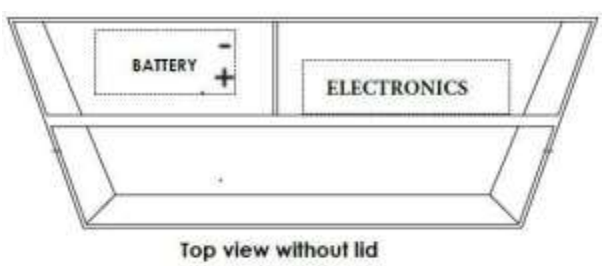
When the wiring was completed and the case was in place, the wire was covered by a long plastic tube as shown on the image on the far right. The length was then adjusted accordingly.

The joystick was then tested with the multimeter on the continuous current. The readings were a success and the multimeter beeps accordingly when the joystick handle moved to the left or right.

7.2.5 Motor Box

Motor box Earlier Designs

The early designs for the motor box were like a trapezoid. The basis was this design was the easy fit of the motor box in the back of the boat.



But, the current design of the motor box is a rectangle. This design was chosen for its simplicity and the fact that we could fit it at the back of the boat by raising its height from the base (mounting using the foam).

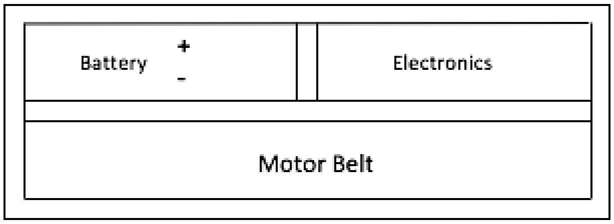


Fig. 2. Overhead View of the current version of the Motor Box

Mounting the Motor Box

At present, the motor box is not high enough so that the pin can be placed in slot in the tiller. As it can be seen in the picture below, there is a gap of about 9 inches from the rudder pin but we want it under 8 inches for more flexible movement of the tiller. To do this, we want to raise the height at which the motor box is placed inside the boat. Raising the height means the box can be snugged inside the boat even further.

The position of the Motor Control Box with respect to the tiller and the back of the boat needs to be determined by using foam pieces. Determining the final dimensions of the foam will require several steps:

(1) Locate the Motor Control Box in a position that works with the range of the tiller.

(2) Develop a foam structure (a slab supported by foam pieces) that will accomplish the result of (1).

(3) Fasten the foam structure to the Motor Control Box using duct tape.

(4) Operate the Tiller with the Servo using the loosely coupled Tiller Adapter Pin.

(5) Affix the Tiller Adapter to the Tiller Adapter Pin and operate the Tiller with the Servo.

(6) Make final adjustments to the position of the Motor Control Box, the Tiller Adapter Pin, and the Tiller Adapter to obtain a smooth motion of the Tiller as the belt moves.

But what can we use to mount the motor box?

After discussion with Prof. Barrett, we decided that we will use foam instead of any other metal, keeping in my mind the benefits of foam over metal. Foam is -

1 Softer
2 Cheaper
3 Can be easily cut into any shape
4 Good insulation properties
5 Readily available

Before mounting the box, it looked like –

After mounting the box, it looks like -

Take a note that we are using two pieces of foam – 1 with a height of 2 inch and 1 piece with a height of 1 inch.

It can be seen that now, the pin fits the slot inside the tiller. However, the movement is not smooth since the pin moves linearly but the tiller has a rotational movement. Work needs to be done to counter that problem.

To make it easier for the pin to move with the tiller, we made changes to the pin. The pin was made shorter and thicker. Also, changes to the tiller were made.

Now, since the pin became shorter, we needed less height for most efficient working. Now, instead of 3 inches, we reduced of the mounting height to 2 inches. That is, instead to two foam pieces, we are back to 1 piece of foam as before. The picture below shows the current and final position regarding the mounting of the motor box -

The foam that we have ordered is Greengaurd Gold certified. Means, the foam underwent some strict tests to be certified before being used for children. So its perfectly safe.

The order request for the foam can be found on SharePoint.

Keeping the Motor Box steady

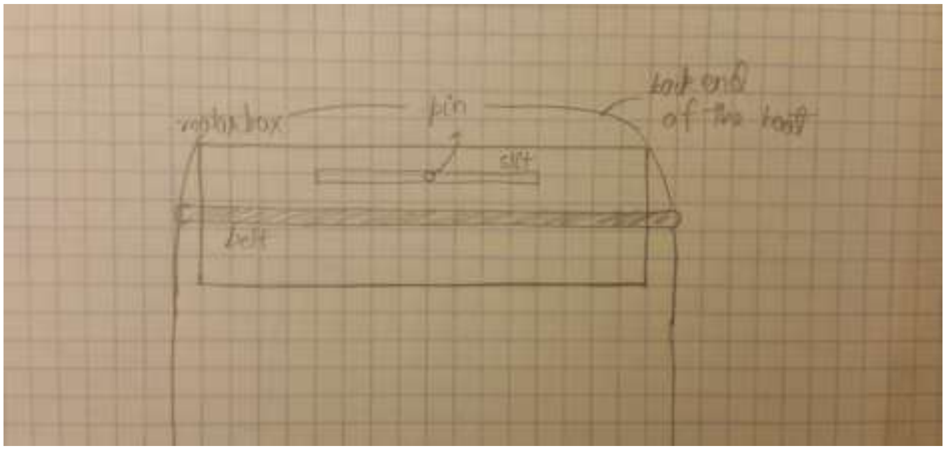
The motor box will be mounted on foam. However, with the boat's speed and movement, the motor box is susceptible to such conditions. If the speed is too high or the boat is made to turn hard on either side, the box will move if it is not tied to the boat. So, we need to keep the box strapped to the boat in some way.

Possible solutions that we came up were -

1. Strapping it to the either side of the boat

Strapping the motor box to the either side of the boat has its merits and demerits. The box will be restricted to move on the sides but the motion towards the inside of the boat will not be stopped. If there is a sudden break, the box will tend to move inside the boat which might hurt one of the passengers. Also, we can only use one long belt in this case, putting all the pressure of the motor box on it.

Strapping to the sides will look somewhat like this -



2. Strapping it to the back of the boat

The major issue of preventing the motor box going inside the box will be clearly solved doing this. Tying to the back of the boat will result in a force on the box towards outside the boat, preventing it to move inwards. The sideways motion will be already restricted by the snug fit of the box. We will use two belts, so the weight will be evenly distributed on each belt.

Strapping to the sides will look somewhat like this (with belt on one side, but there will be a belt symmetrically opposite to this belt)-

The straps were ordered. They came in during the week 14.

The Straps looked like -

Battery Care Instructions

People at camp Riley are no Electrical Engineers. So they need proper guide and steps that they can follow to take care of battery and prolong its life. Taking care of battery not only involves taking care of the electronic parts of the battery, but also how we will handle it. Special instructions are provided to prevent people getting hurt either by battery acid or electric shock.

The document for battery care can be accessed via this link -

https://sharepoint.ecn.purdue.edu/epics/teams/cr/_layouts/WopiFrame2.aspx?sourcedoc=/epics/teams/cr/Semester%20Documentation/Spring%202016/Sailboat/BatteryCareInstructions.docx&action=default&Source=https%3A%2F%2Fsharepoint%2Eecn%2Epurdue%2Eedu%2Fepics%2Fteams%2Fcr%2FSemester%2520Documentation%2FForms%2FAllItems%2Easpx%3FRootFolder%3D%252Fepics%252Fteams%252Fcr%252FSemester%2520Documentation%252FSpring%25202016%252FSailboat%26FolderCTID%3D0x012000D43618A3A550BB478BF50A3ED833EEAB%26View%3D%7B8573E40D%2D932D%2D4036%2DB3CB%2D849351B5719E%7D&DefaultItemOpen=1

Troubleshooting Guide

If the people at Camp Riley face a problem like the battery wont charge, what would they do ? For problems like these, we have set up a troubleshooting guide that they can follow so that they can find the cause of the problem and accordingly tackle it.

At this moment, only the general steps are mentioned in the guide, that will help them in the most simple and common cases.

The document for troubleshooting can be accessed via this link -

https://sharepoint.ecn.purdue.edu/epics/teams/cr/_layouts/WopiFrame2.aspx?sourcedoc=/epics/teams/cr/Semester%20Documentation/Spring%202016/Sailboat/BatteryCareInstructions.docx&action=default&Source=https%3A%2F%2Fsharepoint%2Eecn%2Epurdue%2Eedu%2Fepics%2Fteams%2Fcr%2FSemester%2520Documentation%2FForms%2FAllItems%2Easpx%3FRootFolder%3D%252Fepics%252Fteams%252Fcr%252FSemester%2520Documentation%252FSpring%25202016%252FSailboat%26FolderCTID%3D0x012000D43618A3A550BB478BF50A3ED833EEAB%26View%3D%7B8573E40D%2D932D%2D4036%2DB3CB%2D849351B5719E%7D&DefaultItemOpen=1

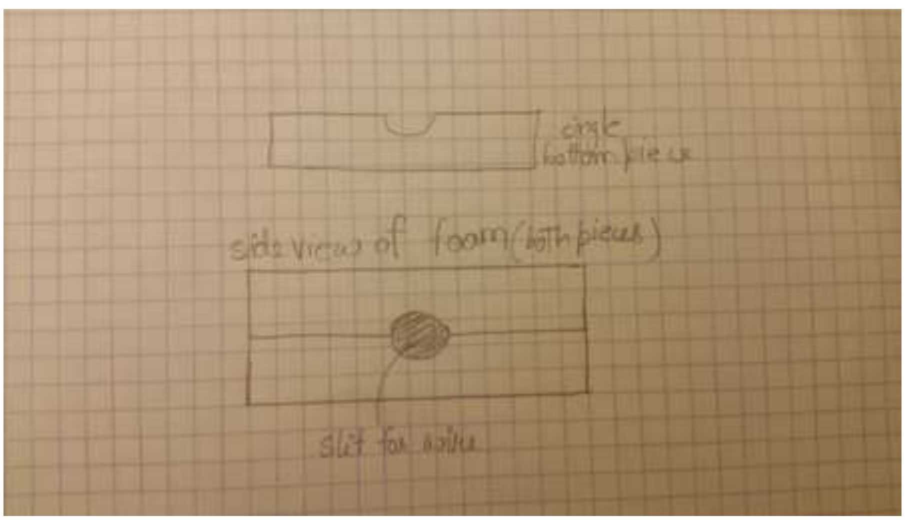
Holding Motor box and foam together

There is one more issue that nobody addressed and the reviewers missed. IT is that the foam and the box will be different parts. But we need some way to keep them together.

Early brainstorming resulted in the following ideas -

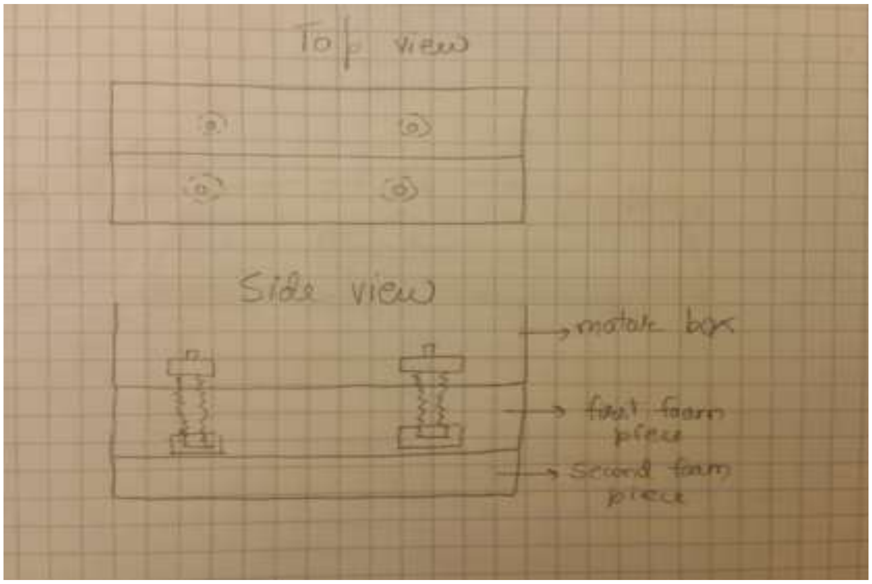
1. Taping them together
2. Glue them together
3. Use a wire through foam

We'll use the idea that we have two foams to our advantage if we want to implement this idea. Since we need to glue the two foam pieces anyway, we will first cut half a slit in one piece and other half in other piece to make a complete cylindrical hole when we glue them together. We can then pass a wire through this hole and strap both the box and foam together.



Or Screw them together

Otherwise, we can use screws to put them together by using few nuts through the bottom of the box. The screw will hold both of them together. Since there is plenty of empty space inside the motor box, there wont be an issue. We don't need to drill holes in both of the foam since both the foam will be glued together anyway. Using screws in just one foam would be enough.



However, we decided in the end that there was no need to work on it right now since the strapping of the box would be enough to hold the box. The weight of the box would not allow the foam beneath it to move.

Change in the Motor Box Pin

As per the early designs of the motor box, the pin on the motor belt was really thin and sleek. It can be seen in this picture -

Although, it had right height for the tiller, the lateral movement through the slit was not smooth. While moving the pin, the pin used to move perpendicular to the slit as well, causing a lot of friction and stopping the pin before reaching either of the ends. So we needed to make few changes to the pin.

Above is the new image of thicker pin on the motor belt. As you can see, it is thicker and it is a bit shorter than the older pin. This new pin fits much better inside the tiller and we performed tests which showed that the movement of the pin is now much smoother than earlier.

The changes to the pin took two weeks, because the mechanic who was making the changes had a lot of work. This delayed our progress for the strapping of the box.

But to accommodate the changes in the pin, we made changes to the tiller as well.

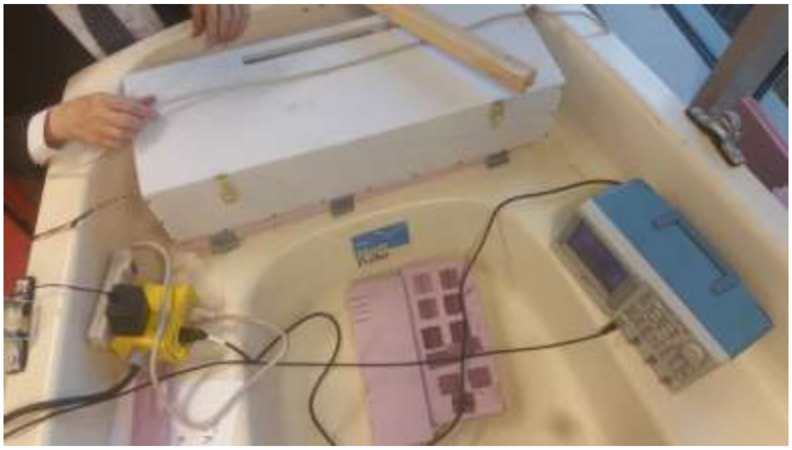
Changes in the Tiller

The tiller in the earlier design was all wood. There was no modification until a decision to thicken out the pin was made. A metal piece like in the image was added to the inside of the tiller. Adding this piece reduced the friction between the pin and the tiller (friction with wood is more). So, the pin was able to slide inside the tiller much more easily now. Also, we saw that the movement of the tiller was smoother. It was able to rotate about 40 degrees on either side from the center of the slit on the motor box.

We wanted to shorten the length of the tiller but it wasn't done because we were getting the right amount of torque from the current length.

Testing of the Tiller and Pin

To test the movement of the motor belt pin with the tiller, we set up the following circuit –



A video of testing can be found on this link - *https://drive.google.com/open?id=0B2TGBPIhpiPrMEdveWNfTmJWNmc*

Steps to set up the circuit –

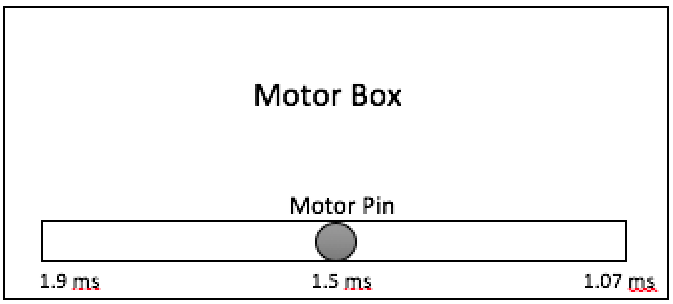
1. Connect the function generator to the oscilloscope.
2. Set up the pulse output signal on the function generator.
3. Set up the right properties for the pulse signal –
   - Frequency = 50Hz
   - Time period = 20 ms
   - Voltage (Low level) = 0 V
   - Voltage (High level) = 5 V
   - Pulse Width – 1.5 ms (For the mid of the slit)
4. Alternatively, set the Voltage(peak to peak) = 5V with an offset of 2.5V. This is equivalent to having 0V to 5V.

5. Set the pulse width for middle duty cycle which is "1500ms"(1.5ms).

6. Make sure to turn the function generator on and we are getting 5 Vpp. Also, make sure you are getting the output from the right channel.

Note – Set the voltage from 0V to 5V and not just 5V (peak to peak) without any offset because 5Vpp means from +2.5V to -2.5V. Supplying a negative voltage to the voltage regulator is not something that you would want because that could harm it.

Changing the pulse width will make the pin to move linearly in the slit on the motor box. The range of the width is from – 1.07 ms (right side) to 1.9 ms (left side).



7.3 Contact Information

7.3.1 Bradford Woods Contact Information

We mainly worked with 3 persons in Bradford Woods. If you need anything from them, followings are their contact information:

- Shay Dawson
  - Director 765-342-2915
- Sheryl McGlory
  - Retreats Coordinator 765-342-2915
  - smcglory@indiana.edu
- Tim Street
  - Associate Director 765-342-2916

Sheryl is also the sailboat expertise in our team. If you have any questions with the sailboat, email her for advice.

7.3.2 Purdue University Resources

There are 2 places on campus that can help with fabricating. One is the machine shop in ECE Building. It's located at the basement. Enter the EE building through the entrance which faces Potter, turn left at the very first corner (only 1 feet from the door) and go downstairs (the stair is behind a door). When going downstairs there is the machine shop. Chuck and Samuel Rainwater are contactors.

Chuck Harrington: chuckh@ecn.purdue.edu

Samuel Rainwater: srainwat@purdue.edu

Another one is downstairs at ARMS Building. Ask professor for more information since we didn't use it this semester.

7.3.3 Faculty Resources

Our professor is Carla B. Zoltowski. She is an expert in ECE and offered a lot help in microprocessor coding. And she is the person who is familiar with our project.

Barrett Robinson is another good resource. He helped us with the motor case design. He is also familiar with the machine shop.

Carla B. Zoltowski: cbz@purdue.edu

Barrett Robinson: robinbar@purdue.edu

More information from previous semesters can be found in the Additional Information document

7.3.4 Battle Ground Middle School

Carla made contact with Battle Ground so we could test our ideas for the interface. Julie works with kids with disabilities at the school and allowed us to work with them. While her email is here, you HAVE TO TALK TO CARLA FIRST. This is at Carla request. Also, she already knows Julie and has worked with her in the past. She will able to work with her and set everything up easily.

Julie Griffin: jgriffin@tsc.k12.inus

8.1 Fall 206 Documentation

8.1.1 Team Members

Abi Lutes
Industrial Engineering
Senior
Co-Design Lead
Project Partner Liaison

Logan Letner
Electrical Engineering
Senior
Co-Design Lead

Eric Slingo
Acoustical Engineering
Senior
Project Archivist

Shengli Sui
Computer Engineering
Senior
Webmaster

Sukrit Virmani
Electrical Engineering
Senior

8.1.2 GANTT

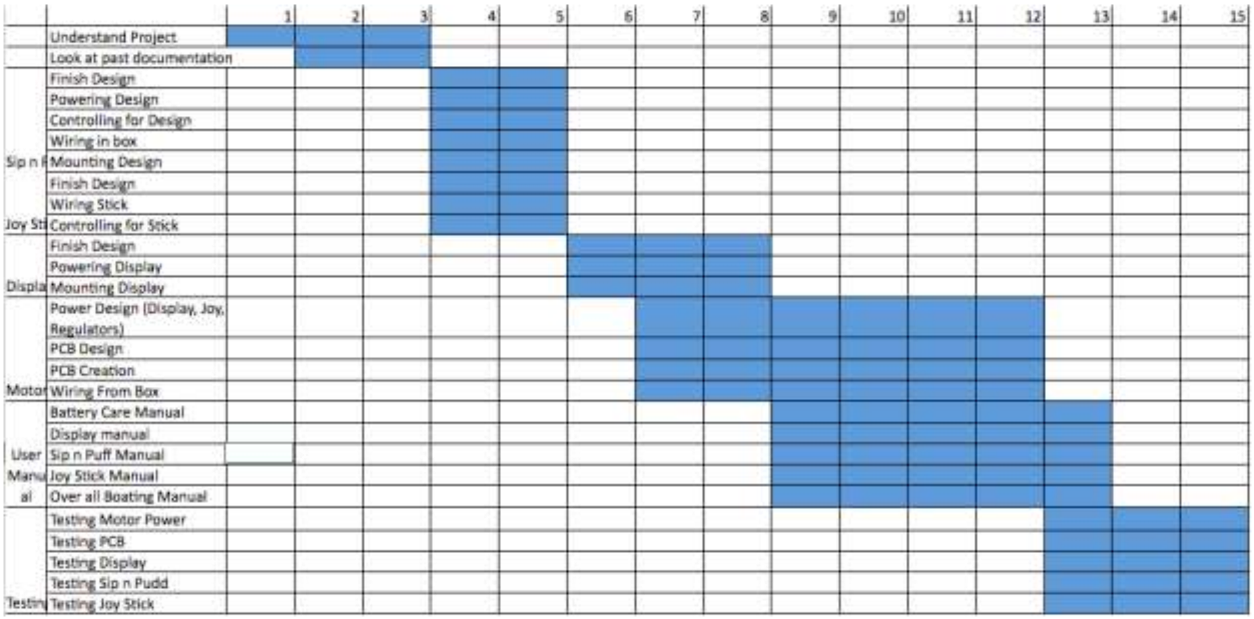


Figure 1: Initial GANTT Chart

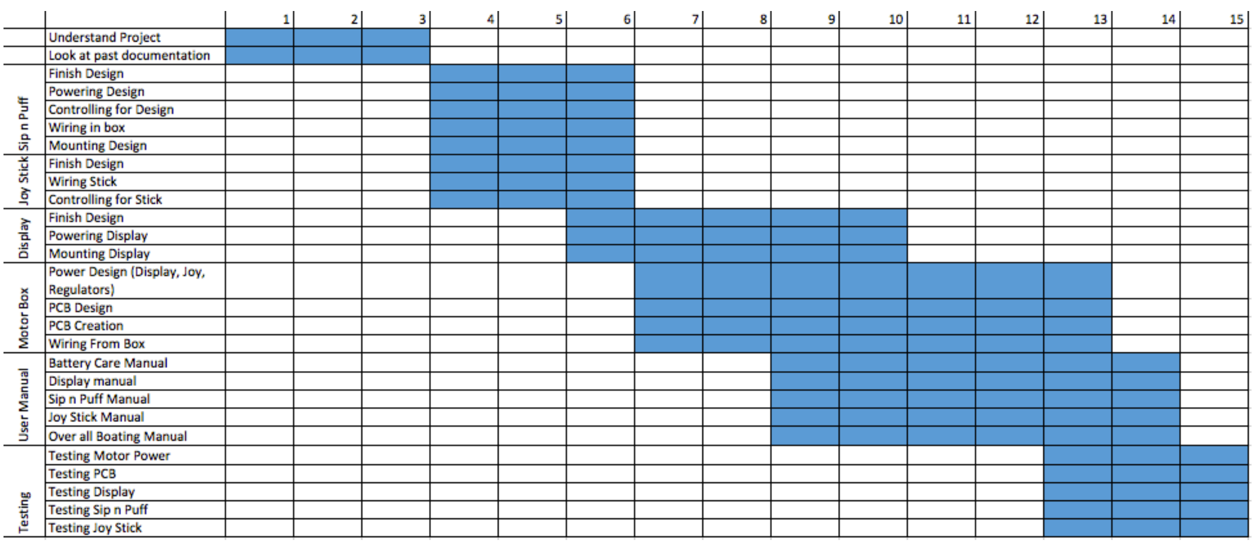


Figure 2: GANTT Chart – Week 8

8.1.3 BUDGET

Item	Allotted Cost
PCB	$100.00
Mounting	$75.00
Wiring	$100.00
Total	$275.00

Figure 3: Initial Semester Budget

8.1.4 User Display

Brainstorming

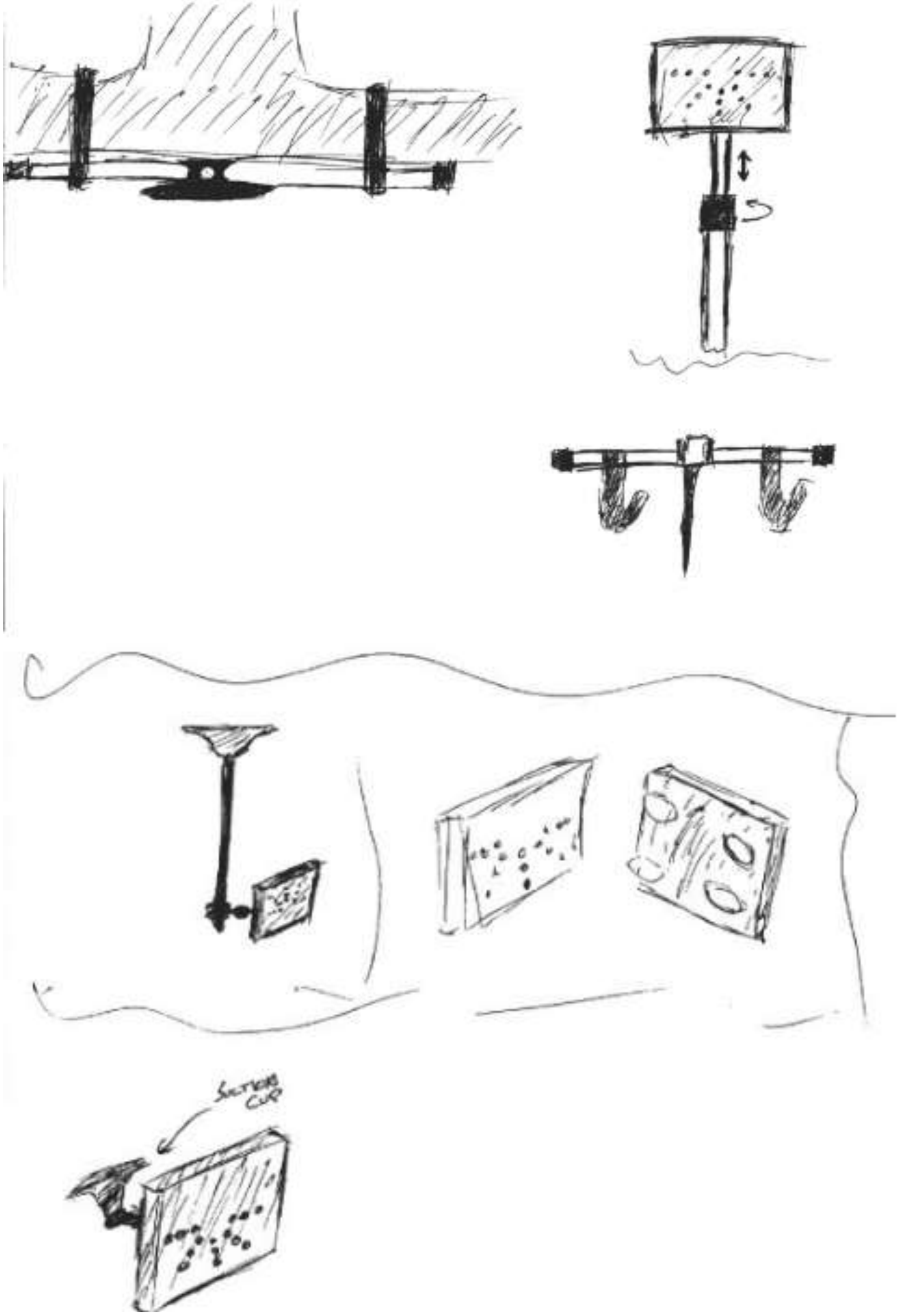


Figure 4: Brainstorming of possible attachment methods for user display

8.1.5 SIP 'N PUFF

Brainstorming

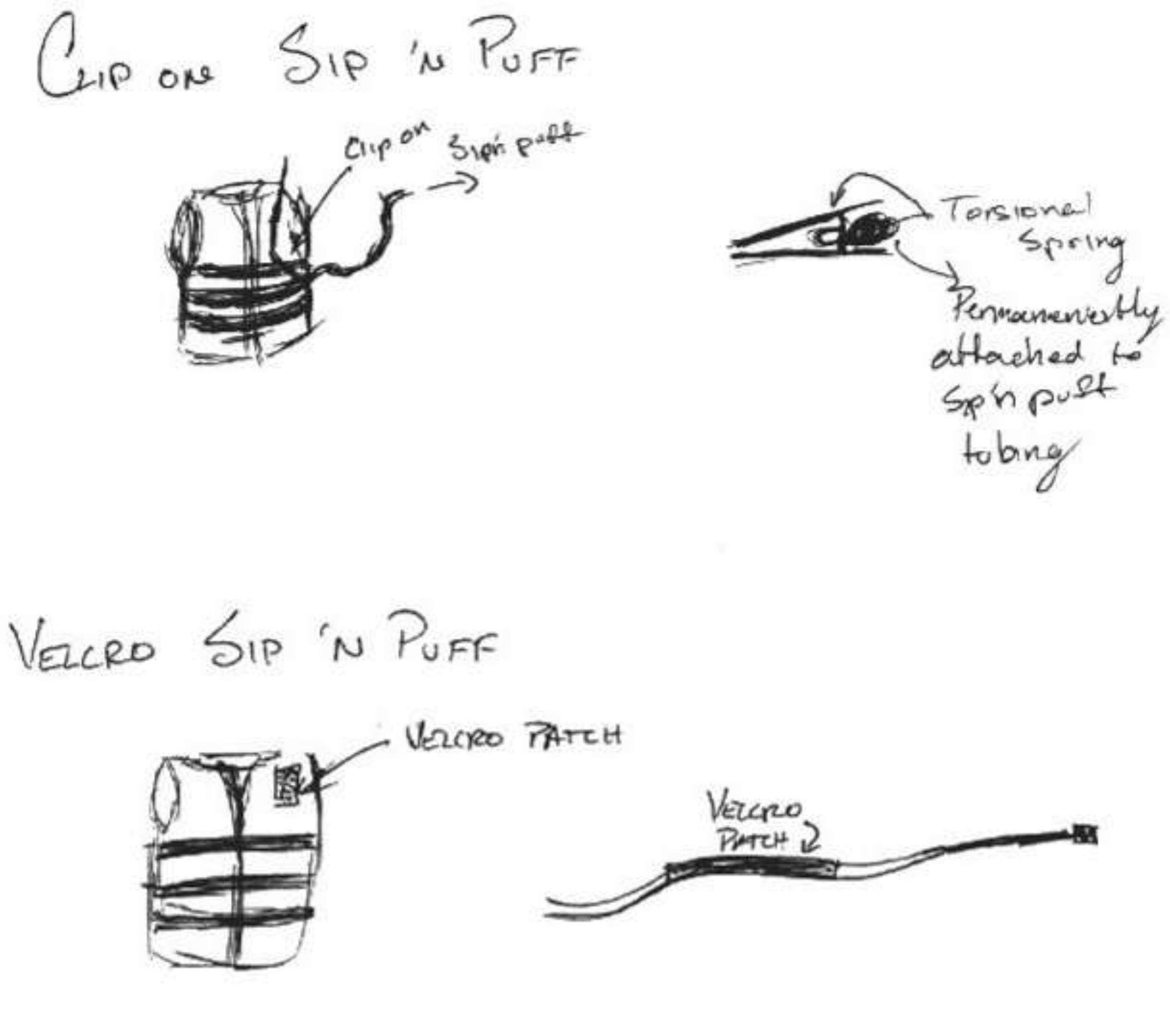


Figure 5: Initial Brainstorming for attaching Sip 'n Puff to life jacket

8.1.6 User Manual

User Display Template

- **General Sailboat Use**
- **Safety Guidelines**
- **Sip n Puff**
    - Attachment
    - Use
- **Joystick**
    - Attachment
    - Use
- **User Display**
    - Attachment

- Use
- **Battery Care Instructions**
  - Charging
  - Attaching
- **Box**
  - Contents
  - Attachment/placement
- **Seating Chart**
- **Troubleshooting**
- **Storage of equipment/boat**

8.1.7 Connection between Joystick and Motor Box

Figure 6 NP3RCS Right Angle Connector

Usage:

- Solid wires from the Joystick onto this connector.

Advantage:

- Users can take the Joystick with them everywhere.
- When they want to use the joystick, they can just plug it into the motor box easily and conveniently.