Human Powered Hydrofoil Bike
Pontoon Floatation

In conjunction with the MobyBike senior project team

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Liquid Ideas

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Abstract

This report documents the brainstorming and design development of the hydrofoil bike floatation device. This project is in conjunction with senior project team *MobyBike*. *MobyBike's* focus is in the development of the bike actuation system, as our team's focus is on designing and developing the floatation device to be incorporated in the final hydrofoil bike design.

Introduction

Our team began collaboration with the *MobyBike* senior project team in February 2013 in order to develop a successful floatation device which will be incorporated into the final hydrofoil bike design. This project will cover the design, build, and test phases of developing the floatation device for a patented human-powered hydrofoil craft. The final design was presented at the Cal Poly Senior Project Expo in May 2013. The floatation device allows the rider of the hydrofoil bike to vary between speeds while always staying afloat. This project is specifically designed for the Mechanical Engineering department at California Polytechnic State University, San Luis Obispo. This project is under the advisory of Sarah Harding and the team consists of Mechanical Engineering seniors Shelley Dangoor and Tyler Brennen.

Management Plan

The team has successfully utilized each other's strengths for each task, including design, theoretical analysis, and technical writing. The team has determined what team members excel in which areas, and has gained confidence in each other to complete tasks. The team has successfully stayed on track throughout the process of this project, following the project timeline seen in Figure A.1.

Tyler Brennen's focus was on the overall design of the pontoon floats with respect to material selection, costs, and analysis. Shelley Dangoor verified relevant calculations, keeping the team organized, documenting the project progress, and making sure deadlines are met. Shelley and Tyler are both liaisons between the *MobyBike* team and *Liquid Ideas* sponsor John Ridgely. Shelley and Tyler began constructing a prototype to test in early April with time to test before Senior Project Expo.

Design Objectives & Specifications

Our goal is to design a floatation device that helps the rider achieve the most enjoyable and human-powered hydrofoil bike experience. Our floatation design will successfully minimize drag and allow the hydrofoil bike to reach the optimal speed to result in full hydrofoil dependency. Our goal is to successfully create the floatation component that satisfies the *MobyBike* cost and design requirements, and therefore ultimately satisfies *Liquid Ideas'* design necessities. The allotted time and resources for this project were scarce, enforcing our team to efficiently design a sufficiently specified system.

With the majority of the project budget being allocated to the *MobyBike* team, our team has a total of $400 to create and test the floats for the hydrofoil bike. As the bike will ultimately be self-supported at optimal speed, the bike will have to carry the full un-submerged weight of the bike floatation. This design specification allocates a total maximum flotation device weight of 20 pounds as specified by the *MobyBike* team.

Liquid Ideas specifies that the aesthetic of the floats on the bike are a desired advantage to the overall bike design. The floats are to be of a sleek nature while still achieving the utility requirement of the design. The floats are to be transportable by means of a standard pick-up truck bed and also need to be user friendly when transferring the bike from the truck to the dock or water surface.

The process as seen in Figure 1 was created for to ensure our team solves the design problem effectively. The process plan takes into account the necessary resources that will be needed to complete our tasks while also following a timed plan. Table 1 summarizes the developed specifications from team *MobyBike* and *Liquid Ideas*' requirements.

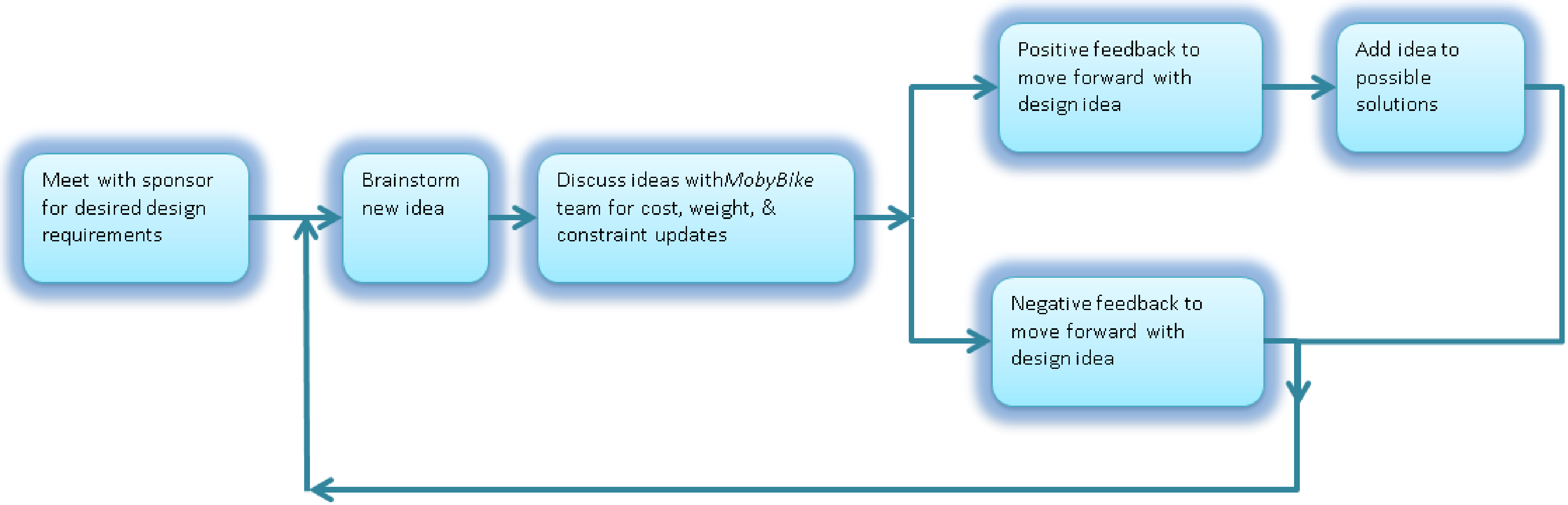


Figure 1. Process plan flow chart to develop best design solution.

Table 1. Formal Engineering Requirements

Specification #	Parameter Description	Requirement or Target	Tolerance	Risk	Compliance Method
1	Weight	20 lbs	Max	High	Analysis
2	Size	10 ft	±1 ft	Medium	Analysis, Similar to Existing Designs
3	Cost	$400	Max	Medium	Analysis
4	Aesthetic	High Quality	Max	Low	Test, Similar to Existing Designs
5	Attachment to Actuation System	Permanently Attached	Min	Medium	Analysis, Similar to Existing Designs

Background

Hydrofoil technology has been incorporated in various boats and human powered vehicles in order to advance water transportation technology. Hydrofoils can be found in bikes ridden on water (hydrobikes), various boats, and water skis. Hydrofoil technology greatly utilizes the speed, stability, and flexibility of the water craft. This project focuses on the specific patent design for a human powered hydrofoil bike. The following background research has been conducted in order to create a strong basis to solve the floatation essential.

The Liquid Ideas Patent

The floatation device for the human-powered hydrofoil is to be incorporated into the hydrofoil actuation system designed from *Liquid Ideas'* patent no. 7662004 (Figure 2). The patent focuses on improving existing hydrofoil actuation designs by strategizing the hydrofoils to oscillate up and down. A control system changes the angle of each foil by means of servo motors, and therefore can optimize the speed of the craft.

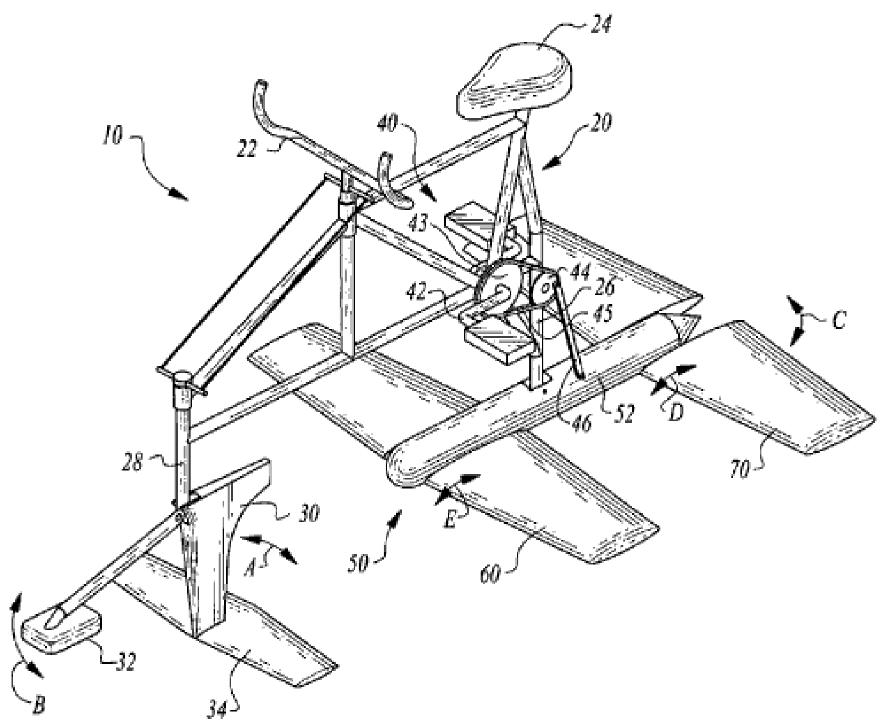


Figure 2. US Patent 7662004 – Hydrofoil water craft with flapping foil propulsion.[1]

The goal for the floatation attachment is to allow the bike to float when stationary atop the water surface, and to lift off from the floats and onto the hydrofoils during human-powered propulsion.

Existing Floatation Designs and Materials

Existing hydrofoil bikes today are comprised of various methods of floatation while some designs solely rely on the hydrofoils to provide lift during acceleration. The added benefit of providing floatation support to the bike, allows the rider to vary between speeds while staying afloat the water surface. Existing floatation methods today include pontoon floats, fiberglass coated solid foam core, and kayak floatation.

Pontoon Floatation

The most common floatation device used in boats, docks, seaplanes, and hydrobike equipment are pontoons. A pontoon is designed to have enough buoyancy to carry a heavy load in water. Pontoons normally have a slim and lengthy design and are constructed of various materials including wood barrels, foam, or air-filled polyester and nylon (Figure 3). The benefit of pontoons is that they submerge to very shallow depths, which reduces the risk of colliding with rocks and other damaging obstructions.

Figure 3. Hydrofoil bike with pontoon floatation. [2]

Fiberglass Coated Solid Foam Core

Fiberglass coated solid foam core can most commonly be seen in surfboards. The surfboard design can withstand large amounts of buoyant force and can travel at fast speeds. The design of the surfboard has a large flat water contact surface, about 30 inches wide, which provides stability and low drag. Surfboard designs also include underwater fins to provide added speed achievement. Due to the solid foam core and the various fiberglass layers, the surfboard design can have a weight up to 35 lbs depending on the length and size of the board. A surfboard floatation incorporated in a hydrofoil bike can be seen below in Figure 4.

Figure 4. Hydrofoil bike with surfboard floatation. [2]

Kayak Floatation

The kayak floatation design utilizes the existing effectiveness of a single-passenger kayak. The user pedals from within the kayak and successfully glides across the water with stability. Disadvantages with the kayak floatation method are that it requires the rider's body to be enclosed within the kayak and that the pedaling motion is horizontal. This specific seated position leaves little room for flexibility and movement for the rider (Figure 5). Also, the large underwater surface area of the kayak hinders the optimal speed that can be achieved.

Figure 5. Hydrofoil bike with kayak floatation. [2]

Fluid Drag Force Analysis

In order for the floatation device to be designed for optimal speed and buoyancy, fluid dynamic analysis needs to be performed. The main concern with the floatation design is the minimization of drag force. The horizontal drag force is due to forces generated by a solid moving through a liquid. The drag force depends on the fluid's velocity and the mass of the solid in contact (Figure 6). Another force to take into consideration when designing water craft is the vertical buoyant force. The buoyant force is important to the water craft because it provides lift and essentially helps keep the craft afloat (Figure 7). The buoyant force can be calculated from the displacement volume of the solid (V) in the liquid and from the specific weight of the solid (γ). The governing equation is therefore:

$$F_{Buoyancy} = V\gamma$$

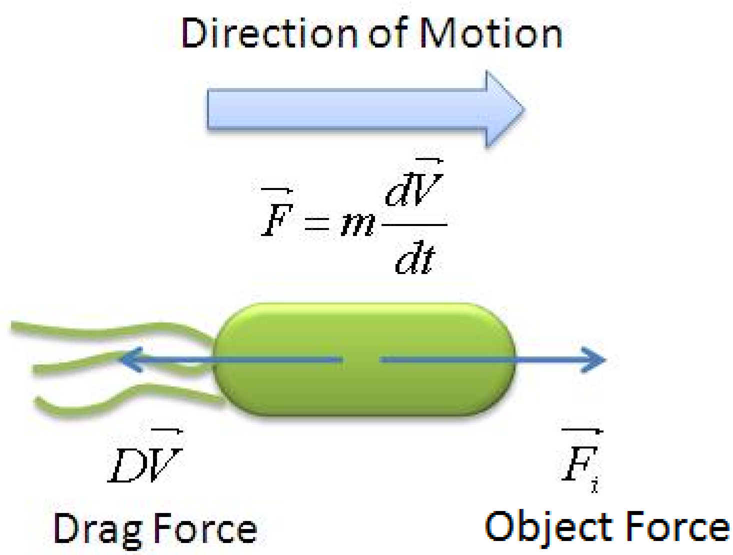


Figure 6. Schematic of drag force on a solid object in motion through fluid.[3]

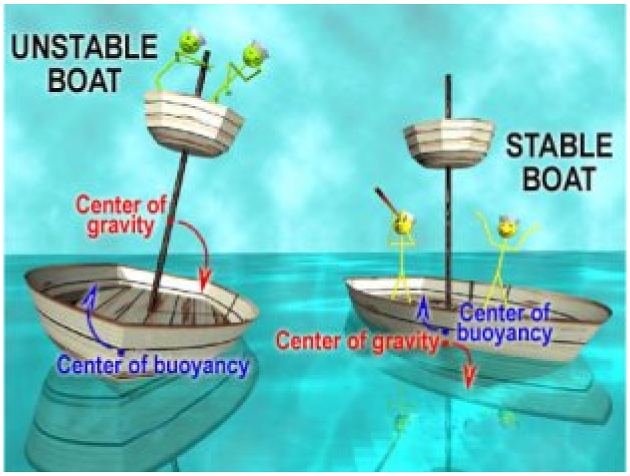


Figure 7. Schematic of buoyancy force on a solid object in a fluid.[4]

A popular and successful water craft design that has low drag and high speed capabilities include crew boats (Figure 8). The success of the crew boat design is due to its small cross-sectional surface area. This smaller, narrow area allows less drag forces on the boat resulting in faster achieved speeds. The small surface area is directly complimented by the long length of the boat in order to reduce the displaced volume. Other successful design features include a blade shaped front and rear to ensure ease of travel through waters.

Figure 8. Long and narrow Crew boat optimizing low drag and high speed.[5]

Failure Prevention in Floatation Devices

With the combination of natural waters and various material composites, water crafts are prone to failure over time. The most common causes of water-related failures are due to cavitation, corrosion, and material oxidization. Cavitation occurs when air (in the form of bubbles) is in contact with the solid in water and causes the material to erode. The most common occurrence of cavitation occurs in sudden changes of the fluid direction. By reducing the speed of the craft, cavitation can be reduced. It is a common challenge to reduce cavitation while designing for optimal speed.

Design Development

We began the design process by creating a matrix to compare different design options. Except for keeping the cross-section circular, we let all the other variables very according to the design. Because the project direction and final product is highly dependent upon cost, each design was manipulated based on a reasonable buoyant force, product availability, cost minimization, water proofing, and providing flotation that can resist rider induced moments on the bike that would induce capsizing. Most pontoons rest with about half of their volume submerged during normal operating conditions. Therefore, we knew we needed at least 250 pounds of maximum flotation per pontoon; the expected rider is about 180 pounds and the bike will weigh around 60 pounds. The buoyant force in Table 2 is the total buoyant force provided by both pontoons. The "4" multiplier on the length column indicates that there will be two collinear pontoons per side to provide extra flotation and moment resistance (if spaced appropriately). Cost is a rough estimate of material costs calculated from the indicated supplier. Surface finish cannot be easily measured with a number so it was excluded, but we figured the material stack up used could allow one to use their intuition to decide which design is best for reducing drag—in this case the fiber glassed urethane core would have the lowest drag coefficient.

Table 2. Pontoon Design Options

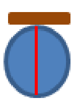
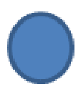
X-Section	Material	Supplier	Density (lbf/ft^3)	Weight (lbf)	Weight with Resin Glass (lbf)	Length (ft)	Radius (in)	Material Volume (ft^3)	Volume Displaced (ft^3)	Bouyant Force (lbf)	Cost ($)
	Aluminum 2024 Sheet Metal	McMaster-Carr	172.8	41.0	41.0	4x2	3.82	0.24	5.09	317.6	800
	Corrosion Resistant Titanium Sheet Metal	McMaster-Carr	281.7	11.2	11.2	3x2	3.82	0.04	3.82	238.4	600
	Polyethylene Hollow Rod	McMaster-Carr	58.8	208.3	208.3	5	8.625	3.55	16.23	1012.8	500
	Urethane Core Fiberglassed with Polyester Resin	George Leone & fiberglass supply.com	4.0	43.6	47.6	10	5	10.90	10.9	680.2	200
	Closed Cell Polystyrene Foam with Wood Block and Glass Line	Foamfactory.com	1.0	4.14	14.14	5.8x2	2.86	4.14	4.14	258.3	240
	Urethane Core with Plastic Mesh and Aerosol Sealant	George Leone & McMaster Carr & Home Depot	4.0	43.6	47.6	10	5	10.90	10.9	680.2	100

Table 2 shows that the first three options are out-of-budget. The urethane core reinforced by plastic mesh and sealed with aerosol sealant would have a high drag coefficient; we also have a bigger budget than one hundred dollars that would allow us to develop a better-performing and better-looking product. The closed-cell polystyrene foam lacks stiffness and aesthetics, but was considered for a cheap alternative to full glassing. Because we would have to buy the closed-cell foam, the closed-cell design ended up being more expensive than completely glassing George Leone's donated foam core. Thus, the urethane foam core fully fiber glassed in polyester resin is the best design option.

At this point, we have verified that shaping and glassing our pontoons is the option best suited for producing a lightweight, low drag, waterproof, and cost effective design. Thanks to George Leone, head machinist at California Polytechnic University of San Luis Obispo, we have a free supply of 4 lb_f/ft^3 density polyurethane foam core; hence, to keep cost low, we based our glassing decisions upon using this free foam.

Because none of our team members were well-educated in the art of fiber glassing, we had to research the different ways to glass. The following table illustrates the different products available to waterproof and strengthen our pontoon:

Table 3. Fiberglass Options and Properties

Fiberglass					
Cloth	Woven Roving	Chopped Strand	Biaxial Fabric	E Glass	S-2 Glass
Low amount of resin needed	Builds thickness	Water proofing	Combination of roving and chopped strand	Typical, low cost surfboard glass	Surfboard glass that is 20% stronger than E glass
Low stiffness, high strength, good finish	Heavy		Saves resin and time	Surfboards have 3-layers of E glass	
Low resin = low waterproofing	Alternated layers with chopped strand		Heavy but high strength and stiffness		

Cost and net weight were difficult to include for Table 3 since each type of cloth has a different layup than the other and can be used in conjunction with other types of weave options to get one's desired performance out of the final product. Using woven roving and chopped strand or biaxial fabric are the heavier options that provide the best stiffness and strength is that is what the sponsor wants out the pontoon.

Table 4 depicts the different options we have with polyester resin. Epoxy resin was not considered since it is a high-performance resin that is about 2.5 times more expensive than polyester resin and is best used with lightweight Styrofoam to save weight. Epoxy has become very popular with surfboards recently because they can significantly increase strength, remove the need for a stringer, and can be lighter than traditional surfboards. In the end, polyester resin was chosen because resin is the highest expense for the project.

Table 4. Polyester Resin Options and Properties

Resin		
Layup	Finishing	General Purpose
Air inhibited	Cures with waxy surface	Used for both layup and finish
Leaves surface tacky for better buildup	Wax can be sanded or dissolved to get desired finish	Looked down upon by professionals

With our new foundation for fiber glassing and advice from different glassing forums, we were able to compile three different possible options for how to glass each pontoon. Table 5 gives cost estimates for three different glassing techniques that should be of relatively equal stiffness, strength, and waterproofing. The basis for these options is the standard three layers of E glass shapers use to glass their surfboards.

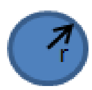
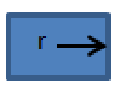
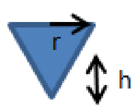
Table 5. Fiberglass Comparison

	E Glass	S-2 Glass	Biaxial Fabric with Cloth
Density (oz/yd^2)	6	3.7	10 (fabric) 3.7 (cloth)
Glass Weight (oz/yd^2)	18	11.1	17.4
Resin to Glass (oz/oz)	2:1	2:1	1.5:1 (fabric) 1:1 (cloth)
Buildup	3-layers	3-layers	Cloth, Fabric, Cloth
Cost ($)	142.93	257.80	166.78

From a cursory inspection of Table 5, it appears that the biaxial fabric layup with cloth on the bottom and top would be the lightest and possibly the strongest of the three options since the amount of resin should be the least. It is important to note, that both pontoons are expected to have about 2.91 square yards of surface area. This design would provide a maximum buoyant force of 340 lbs per pontoon. Furthermore, the amount of resin needed for all three options was a gallon of general purpose or layup resin with a pint of finishing resin. These amounts were all constant because limited amount of resin containers meant a small difference in resin needed still required the same oversized resin container.

Next, Dr. Ridgely, our sponsor, requested that we evaluate different cross-sectional designs to minimize drag force induced by the water on the pontoons. Assuming a constant surface finish among each cross-section and a pontoon length of ten feet, we developed a table of 4 different designs (Table 6). To produce the best aerodynamic design, the amount of surface area that would be exposed to the viscous fluid (water) has to be minimized.

Table 6. Pontoon Cross-section Optimization[6]

Cross-Section	r (in)	Bouyant Force Needed (lbf/pontoon)	Volume Needed (ft^3)	Area Needed (ft^2)	Governing Equation	Surface Area Exposed to Fluid (ft^2)
	5	125	2	0.2	V = (LD^2/8)(Θ-sin(Θ)) SA = 2πrL(Θ/360)	11.32
	5	125	2	0.2	V = (LD^2/8)(Θ-sin(Θ)) SA = 2πrL(Θ/360)	11.32
	5	125	2	0.2	V = 2rLh SA = (2r+2h)L	10.73
	5	125	2	0.2	V = (Ltan(60)h^2)/2 SA = 2hsin(60)L	11.77

Two columns in Table 6 should be noted—cross section and surface area exposed to the fluid. These two columns show that the rectangular cross-section would be the best performing design and by virtue, the triangular cross-section would be the worst-performing design of the four. From fluid mechanics, we know that sharp edges are problematic for boundary layers formed along the pontoon surfaces, so deburring the edges and coming up with a hybrid design that mixes the half-circular and rectangular design would be our best option. This design would also make glassing simpler as a top and bottom layer would have to be applied individually when glassing the pontoons. The simplest surface to glass is a flat surface followed by a curved surface; the hardest surfaces to glass are uneven or sharp-edged surfaces.

Unfortunately, it is difficult to model what exact shape the pontoons will take. We can only approximate what the middle cross-section and ends will resemble because shaping is an art form much more than a concrete manufacturing process. This is why surfboard shapers are so diverse and their boards have a unique character and personality that differ from other shapers. Hence, our design will be a combination of our results from table 6 and race boat design as seen in figure 8.

After further communication with our sponsor, our team was encouraged to begin testing with the E-glass fiberglass on foam core with polyester surf and gloss resin. As mentioned, E-glass is the standard fiberglass weave used for surfboards and is the cheapest of the three options presented in table 5.

Fiberglass testing will begin at the beginning of spring quarter. Our goal is to optimize the correct ratio of resin to fiberglass in order to improve water proofing, weight, and strength. We expect the ratio to be somewhere around 2:1 as far as resin weight to glass weight. Our hope is to be able to test 3.7oz and 6oz E-glass. 3.7oz is used on short boards, and 6oz is used on long boards. The higher density weave is supposed to provide more strength. 3-layers of fiberglass is the typical layup for surfboards, but it is our goal to be at 1 or 2 layers to save weight. Our sponsor indicated that the pontoon does not have to be super strong, but should be resistant to minor scratches and dings that could compromise the waterproofing and performance of the pontoon. These tests do not need special or expensive equipment and can be conducted in virtually any environment.

For safety, we will need respirators or masks to protect ourselves from the resin fumes. We will also need a soft stand to rest the foam on and a special resin spreading tool. Most, if not all, of these items can probably be borrowed from Dr. Ridgely or Mr. Leone.

We shall also test the possibility of cutting small foam compartments out of several regions of the pontoon to save weight. Without the extra foam, the pontoon should be lighter, but the fiberglass may lose some of its structural strength. Hence, if weight becomes an issue after we determine the proper glass layup for our pontoons, these tests will be conducted. Otherwise, the pontoons shall be left as is to ensure consistent pontoon rigidity and strength throughout, as well as move us closer towards project completion.

Overall, the following design process has provided us with a rough design and testing plan to be executed over the final eight weeks of spring quarter. It shall be fairly fast paced, but with the known glass we are using, testing plan, and general shape of the pontoon we have a great starting point to manufacturing some light-weight, high-performance pontoons.

Product Realization

Final Prototype Design

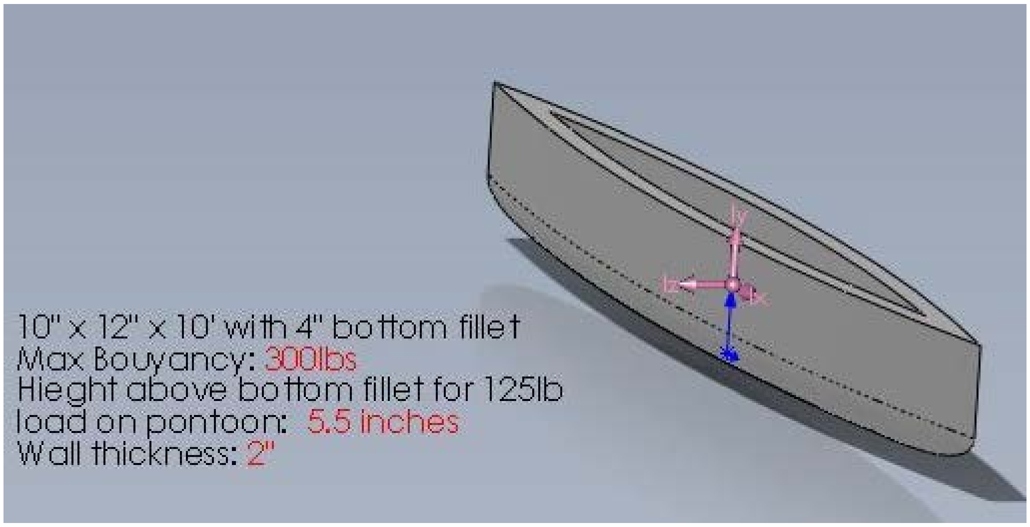


Figure 9. Final design model.

Our final design ended up being a close representation to our original plan for manufacturing. We did not get to test and compare 3.7 oz and 6.0 oz E-glass cloth. We ended up using 6.0 oz E-glass cloth as Dr. Ridgely handled procuring this item. We used a *Solidworks* model with a 4" fillet and 2" shelled-out feature to shape our pontoons against (Figure 9). We played with different layups to see which volumetric design gave us enough buoyancy to spec while meeting the weight requirement, since changing the width, height, and fillet changed the amount of weight saved by hollowing out the pontoon. We then used the plotter to make 1:1 cutouts of the top perspective shape and 1:1 cutouts of specific cross-sections (Figures 10 & 11).

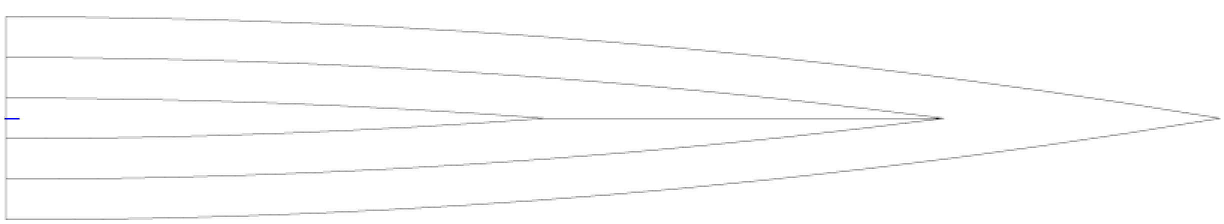


Figure 10. Top view of pontoon shape with hollowed layers.

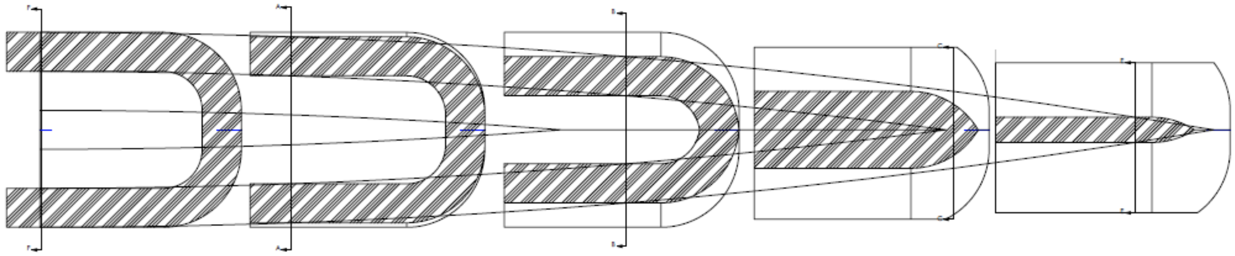


Figure 11. Cross-sectional view of pontoon contours.

Furthermore, we needed to determine the attachment holes for the pontoon so that the rider will be properly balanced when seated on the hydrofoil bike. Using mass property tools on the hydrofoil bike model and cycling forums, we determined the center of gravity to be 5" behind the crank shaft. We also put the attachment holes 7" above the bottom of the floats since *Solidworks* determined that point would provide 350 lbs of buoyancy for that amount of water displacement provided by the floats. The design for the attachment holes were not determined in the CDR and took about two weeks to brainstorm and execute a design plan for making the attachment for the floats to the frame to work without changing the initial design requirements of the project. By talking to Dan Shannon, a local custom marine part specialist, we were able to determine that using concentric steel tubes glassed into the float with cotter pins to secure the floats to the frame would be our best option. Steel tubes were used because they were cheaper and lighter than getting aluminum tubes to concentrically fit over the frame. The material was highly dependent on availability, since a tight fit between the float and frame was the most important design criteria to satisfy. Lastly, we were lucky enough to have George Leone's help with fiberglassing our floats. Without him, our attempts at glassing would have fallen short of our current product and would likely have resulted in weak spots around the pontoon and possible spots were water could penetrate the floats. However, George changed our initial design hopes of using a light amount of resin; this was probably a good design change. We used 2-3 times the amount of resin originally estimated. We used two resin coats instead of one and applied them liberally. One coat was a layup coat and the second was a finishing coat.

The pontoons are 30lbs each with the steel tubes. This means floats already make up the entire weight limit of the original design spec of 60 lbs. This is the case because fiberglassing was the best method for manufacturing we had. We had $400 worth of foam donated to us from George Leone and his HPV club and $50 of resin donated to us from the hangar. Therefore, our own expenses only totaled $105.00 and we are not sure how much Dr. Ridgely's E-glass expense was. For this project to work in the future, we would need a significant increase in funding to build carbon fiber pontoons so that we can have light-weight, high-performance pontoons. Also, the manufacturer of these pontoons would need to be highly experienced in this manufacturing method. One of the downfalls of our floats is that we are relatively new to shaping and the floats were our first real attempt at completely fiberglassing a large structure. Even though Dr. Ridgely showed great satisfaction with our final product and George Leone was very impressed with our job shaping and fiberglassing, there are obvious imperfections in the floats that show it was manufactured by a novice hand. Overall, I think this was a good project to help to determine the viability of a hydrofoil bike without risking a huge investment and learning the certain pitfalls building a such a device.

Manufacturing Processes

The foam core pontoons were manufactured at the Cal *Poly Student Projects Machine Shop in the Hangar.* The pontoons were entirely manufactured by students Shelley Dangoor and Tyler Brennen with the advisory of shop lead George Leone. The following steps and figures outline the complete manufacturing process of the pontoons. The total manufacturing process took 7 weeks to complete.

STEP 1: Cut foam sheets into rough shapes & glue (3 weeks)

Each foam sheet is 2" thick which was cut on the bandsaw to the rough outline of the pontoon shape (Figure 12). The layers were then glued together in an overlapping fashion to increase strength (Figure 13). The glue used with the foam was Gorilla Glue, which bonds to the foam with water. The glue expands while drying, resulting in full surface contact with the foam.

Figure 12. Foam sheets are cut to rough shape on bandsaw.

Figure 13. Foam sheets are glued to be ready for shaping.

STEP 2: Shape foam pontoon contours (2 weeks)

The pontoons were sanded by hand and shaped to resemble the contours designed in the *Solidworks* model. Sanding was done in a well-ventilated area with the use of respirator masks (Figure 14).

Figure 14. Foam is sanded to remove excess glue and shaped into designed contours.

STEP 3: Install steel tubes for bike frame attachment & glue reinforcements (1 week)

Steel tubing was turned on the lathe in order to slide flush and concentrically with the bike frame tubing. Foam inserts were glued in the hollow pontoons to add reinforcements (Figure 15). Holes were drilled to fit the cotter pins that will secure tubes in place, and finally the tubes were glued into the pontoons (Figures 16-18)

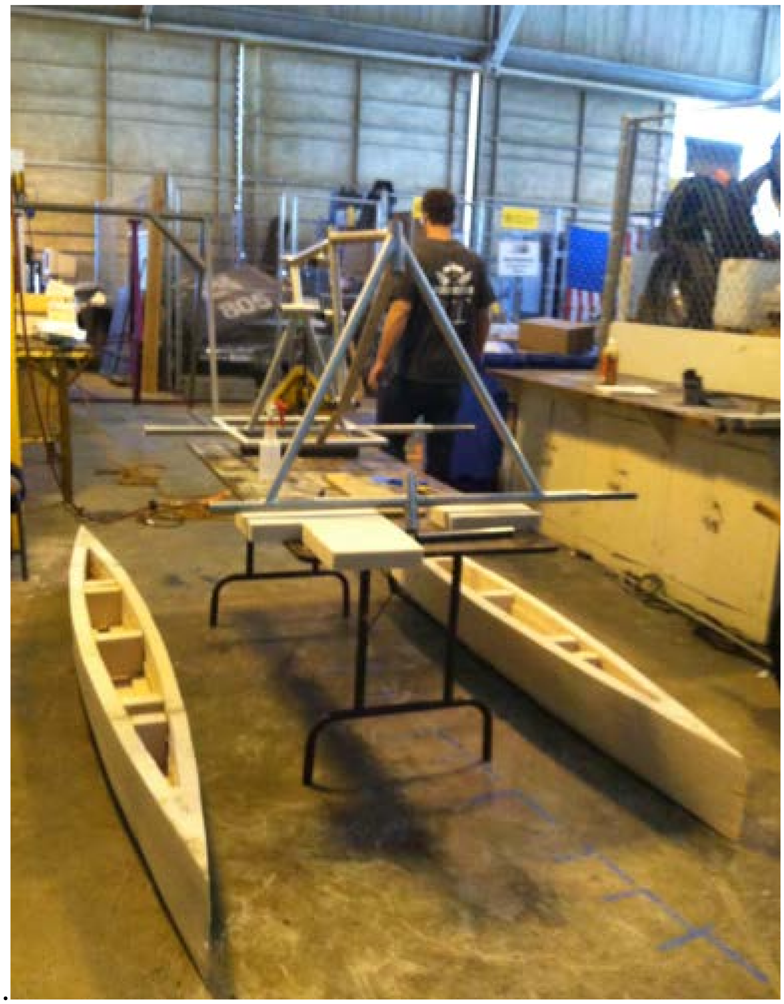


Figure 15. View of hollow pontoons with foam inserts as reinforcements.

Figure 16. Steel Tubes are turned on the lathe to fit concentrically with bike frame tubes.

Figure 17. Holes are drilled in steel tubes for cotter pin placement.

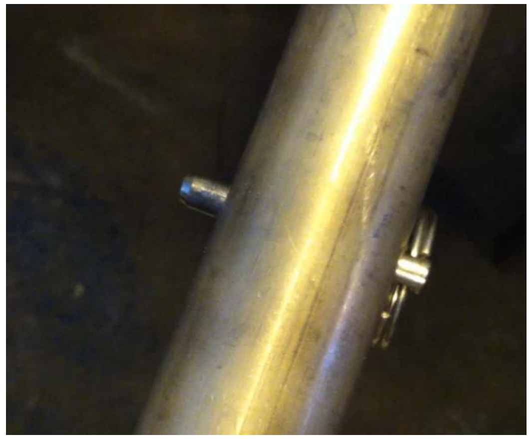


Figure 18. Cotter pin lockage in steel tubes.

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STEP 4: Fiberglassing and surface finish (1 week)

Each pontoon was fiberglassed by laying the dry biaxial cloth, applying the polyester resin, and then setting the pontoons in the sunlight to cure under UV exposure (Figures 19-21). In order to save weight and resources, only one layer of fiberglass was applied, with a reinforced layer on the top and bottom of the pontoon. After each pontoon was completely fiberglassed, a surfacing agent was then applied and cured in UV light to create a smooth surface finish.

Figure 19. Biaxial fiberglass cloth is laid down on pontoon.

Figure 20. Polyester resin is then spread evenly over cloth.

Figure 21. Pontoons are set to cure in UV light (10 minutes).

Design Verification

Testing

Testing of the pontoons' ability to comply with design specifications occurred at Lopez Lake in Arroyo Grande, CA. The pontoons and bike frame were transported to the lake on a standard pick-up truck bed. Once arrived, the pontoons were each carried down to the lakeside by one individual, and then assembled to the bike frame. The pontoons were easily transportable and took a total of 5 minutes to be secured into the bike frame. The assembled hydrofoil bike was then set into the water to be tested for buoyancy, stability, and material strength.

A summarization of the test descriptions and results are shown below in Table 7.

Table 7. Test Procedures & Results

Test Description	Desired Result	Actual Result
Durability: Pontoon is dropped onto concrete from a height of 3 ft	Pontoon can withstand dents, breakage	Pontoon withstands any damage
Buoyancy: Assembled bike is loaded with rider Assembled bike is loaded with maximum weight of 660 lbs (Total 750 lb with bike frame)	Water level does not go above steel tubes	Water level is below steel tubes with single rider. At maximum weight, the water level is 1" above pontoon top surface
Stability: Rider loads bike by climbing atop one pontoon. Rider stands on pontoon. Rider jumps on pontoon	Pontoon is able to stabilize bike and avoid capsizing	Pontoon successfully withstand any instability, allowing rider to comfortably board hydrofoil bike.

Figure 22. Testing of Completed Pontoons. (From left to right) Rider is stable on bike, rider climbs aboard pontoon from water side, rider stands on pontoon, rider tests capsize prevention.

Conclusion

Overall, the final pontoon design and implementation is satisfactory with the sponsor's specifications. The pontoon floats are easy to handle and are lightweight. They are conveniently removable from the bike frame for ease in transportation and storage. The pontoon floats are exceptionally balanced and stable while in the water, which makes the rider's experience more enjoyable. As this was the first prototype floatation device for *Liquid Ideas*, the testing of the patented hydrofoils can effectively be tested for verification.

Appendix A

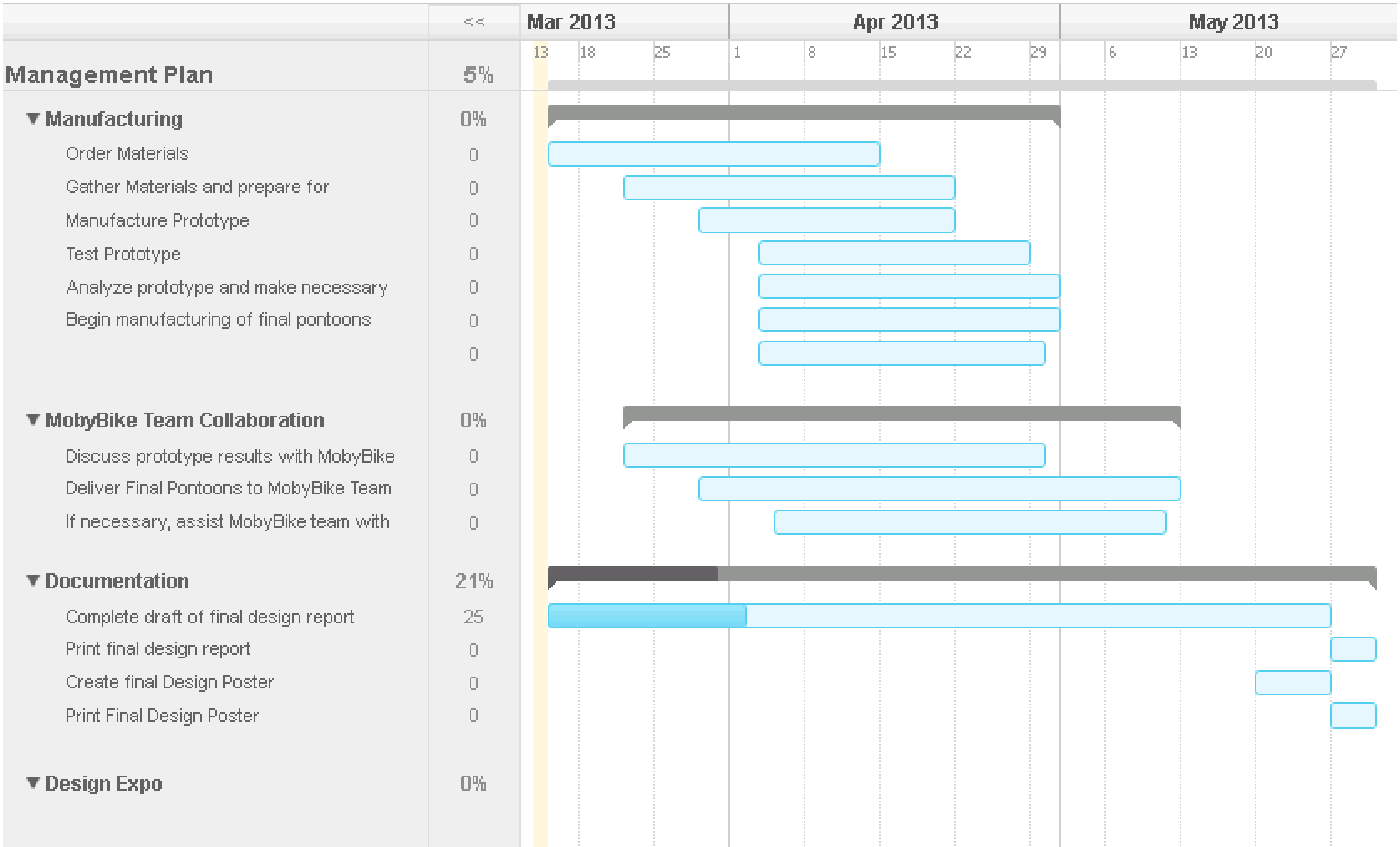
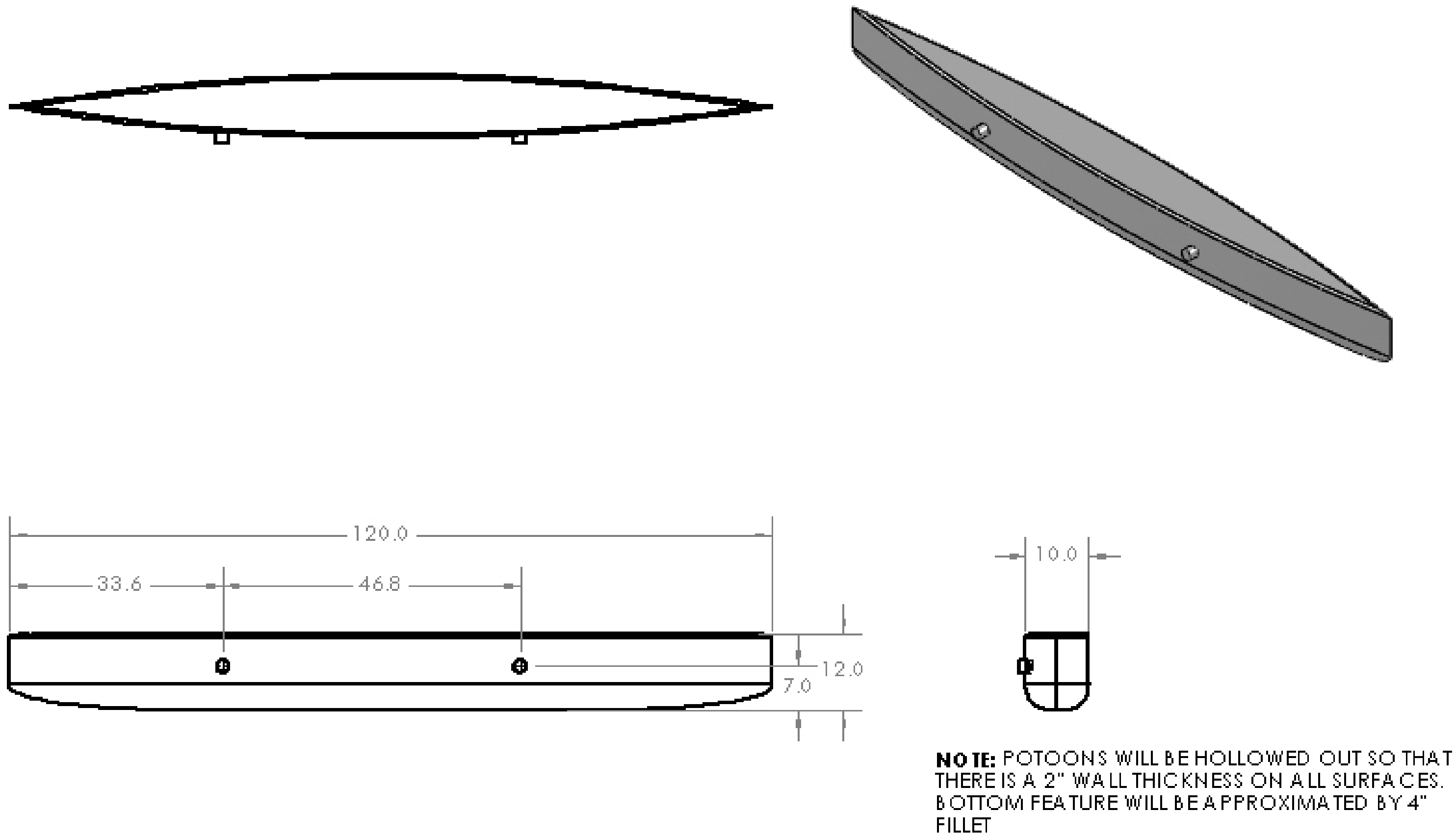


Figure A.1. Management Plan



Mechanical Engineering CAL POLY

DRAWN BY: TYLER BRENNEN	INIT: TB	CKD BY:	INIT:
TOLERANCE: N/A	UNITS: INCHES	MATERIAL: POLYURETHANE FOAM	
NEXT ASSY:	SCALE: 1:1	TITLE: POTOON FLOAT	
DWG #: 001	DATE: 6/11/2013	GROUP: MOBY FLOATS	

Figure A.2. CAD Model of Pontoon

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