EML 4550: Roboboat 2020

Critical Design Review: Hardware

Team Introductions

Brandon Bascetta
Mechanical Design Lead

Courtney Cumberland
Manufacturing Lead

Toni Weaver
Systems Lead

Sponsor and Advisor

Technical Advisor
Dr. Joshua Weaver
Senior Scientist of Autonomy,
NSWC

Engineering Mentor/Academic Advisor
Damion Dunlap
Mechanical Engineering,
FSU Panama City

Brandon Bascetta

Objective

Design a new boat for the 2020 Roboboat competition.

Brandon Bascetta

Project Scope

The scope of this project is to design and manufacture the physical boat hull that can navigate the specific tasks that complies with the rules of the 2020 Roboboat competition.

Brandon Bascetta

Project Requirements

- Boat shall be positively buoyant
- Boat Design shall have detailed drawings
- Boat shall be manufactured to withstand normal use during testing and competition
- Boat shall have basic motor mixing and RC control
- Boat shall be capable of basic waypoint navigation

Brandon Bascetta

Project Background

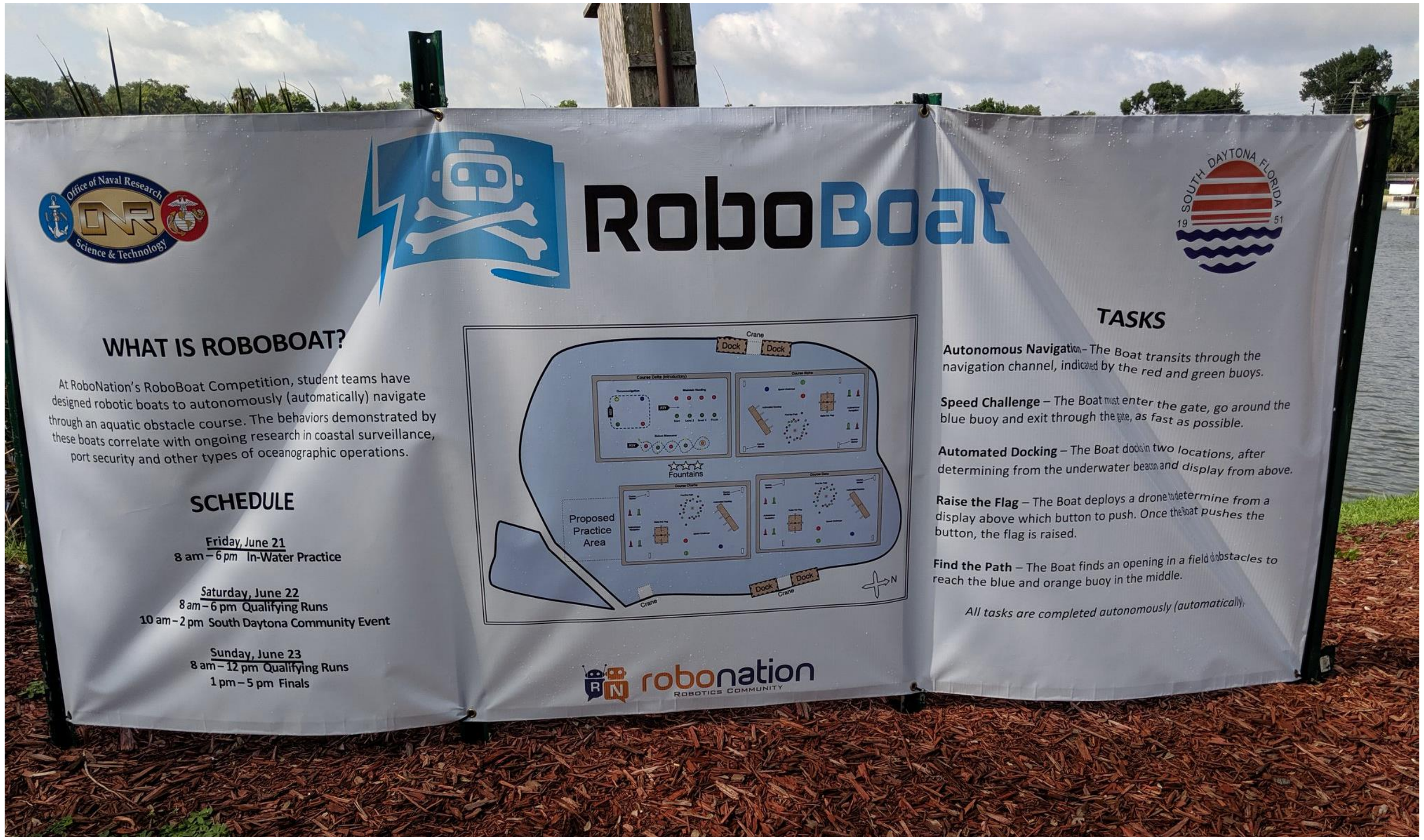
Toni Weaver

Project Background: Roboboat Competition

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

Toni Weaver

Project Background: Roboboat Competition



- International Competition
- Held in Daytona
- Each team is tasked with designing and manufacturing their own boat and software.

Toni Weaver

Project Background: Roboboat Competition

Toni Weaver

Project Background: 2019 Roboboat Team

SEMINOLE COAST

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

Toni Weaver

Project Background:2019 Roboboat Team

SEMINOLE COAST PRESENTING TO COMPETITION JUDGES FOR STATIC JUDGMENT

In the competition, the team was judged on everything including:

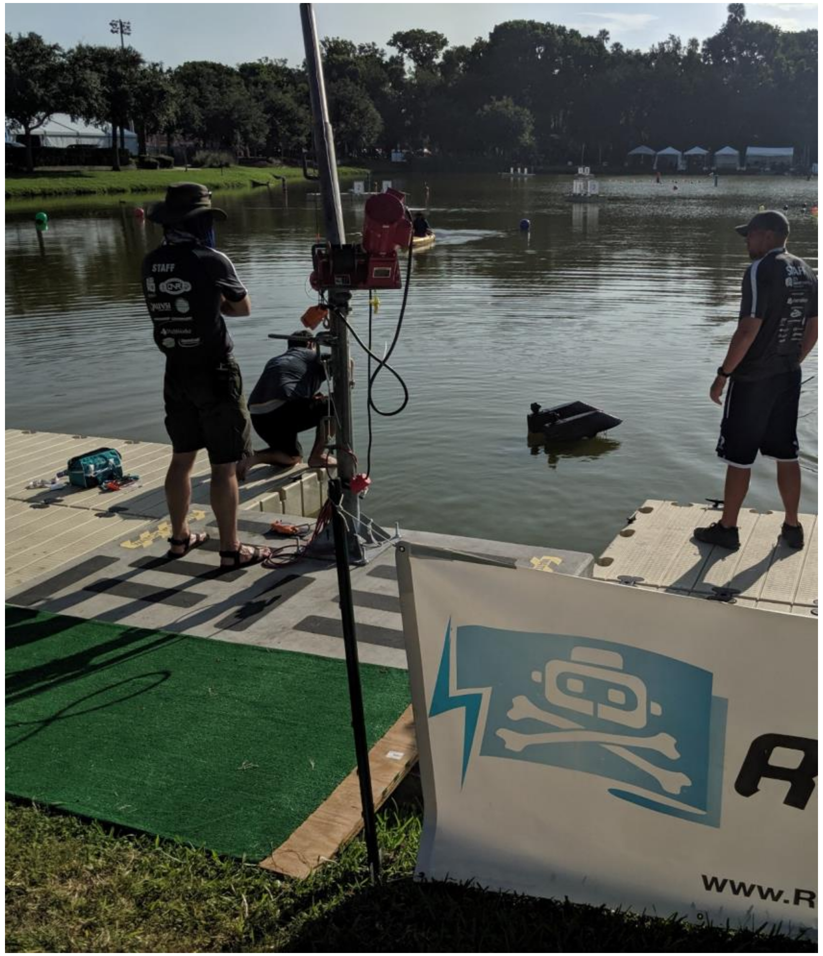
- our media presence
- technical paper
- team uniform
- static presentation
- team performance
- Boat aesthetics

Toni Weaver

Project Background:2019 Roboboat Team

Team did well in static judgement, however, the boat hull itself was not designed using any type of design method, and therefore flipped.

1	University of Michigan (UOFM)	314.602
2	Hagerty High School (HHS)	290.576
3	Institut Teknologi Sepuluh Nopember (ITSN)	282.542
4	Embry-Riddle Aeronautical University (ERAU)	274.07
5	Florida State University / Gulf Coast State College (FSUGC)	267.769
6	University of Puerto Rico, Mayaguez (UPRM)	267.389
7	Georgia Institute of Technology Aerospace (GIT)	264.35
8	Tecnológico de Monterrey (VTEC)	257.965
9	Universitas Indonesia (UI)	246.645
10	University of Louisiana at Lafayette (ULL)	238.97
11	Military Technical College (MTC)	222.453
12	Universitas Diponegoro (UNDIP)	195.14
13	University of Colorado - Boulder (CUB)	182.944



Toni Weaver

Project Background: 2019 Roboboat Team

VECTORNAV
Embedded Navigation Solutions

BlueRobotics

Velodyne
LiDAR

Design Requirements

Courtney Cumberland

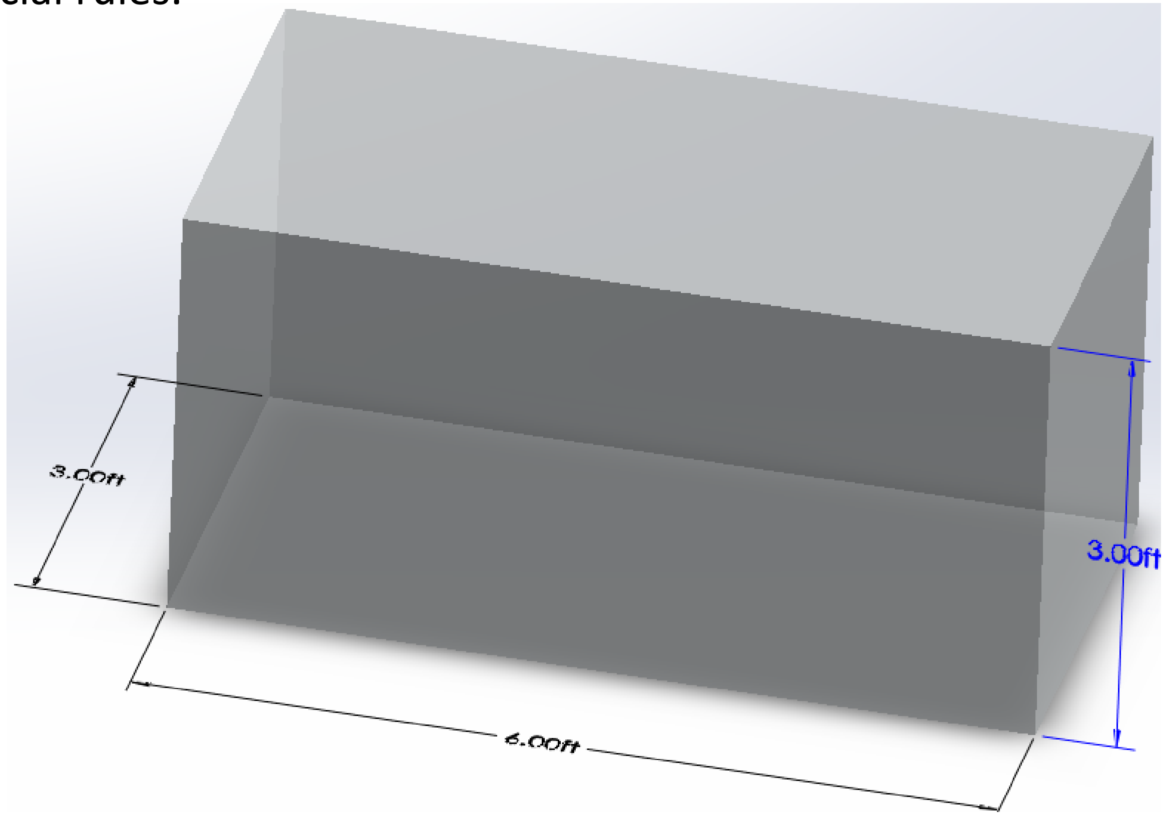
Design Requirements

The boat size and weight are issued by Roboboat official rules.

Table 1: Weight and thrust scoresheet

Parameters	Points
ASV + UAV weight > 140 lbs.	**Disqualified!!!**
140 lbs > ASV + UAV weight > 110	-250 - 5*(w - 110)
110 lbs > ASV + UAV weight > 70	2*(110 – w)
ASV weight + UAV weight ≤ 70 lbs	80 + (70 - w)
Dimensions greater than: - three feet of width or - three feet of height - six feet of length	**Disqualified!!!**
Thrust (t) vs weight (w)	*100*(t / w)*

https://robonation.org/programs/roboboat/



Courtney Cumberland

Design Requirements

Roboboat rules state specific requirements that each boat must possess:

- **Deployable**: Must have 3 or 4 point harness attachment locations
- **Energy source**: Must be battery powered.
- **Kill Switch**: Must have a physical kill switch
- **Size**: Must fit within a six feet, by three feet, by three feet "box".
- **Surface**: Must float or use ground effect of the water surface
- **Towable**: Must have a tow harness installed at all times.
- **Visual Feedback**: Teams are required to implement a visual feedback system

https://roboboat.org/about/

Courtney Cumberland

Design Requirements

In addition to the requirements specified by the Roboboat rules, there are also environmental and functionality considerations.

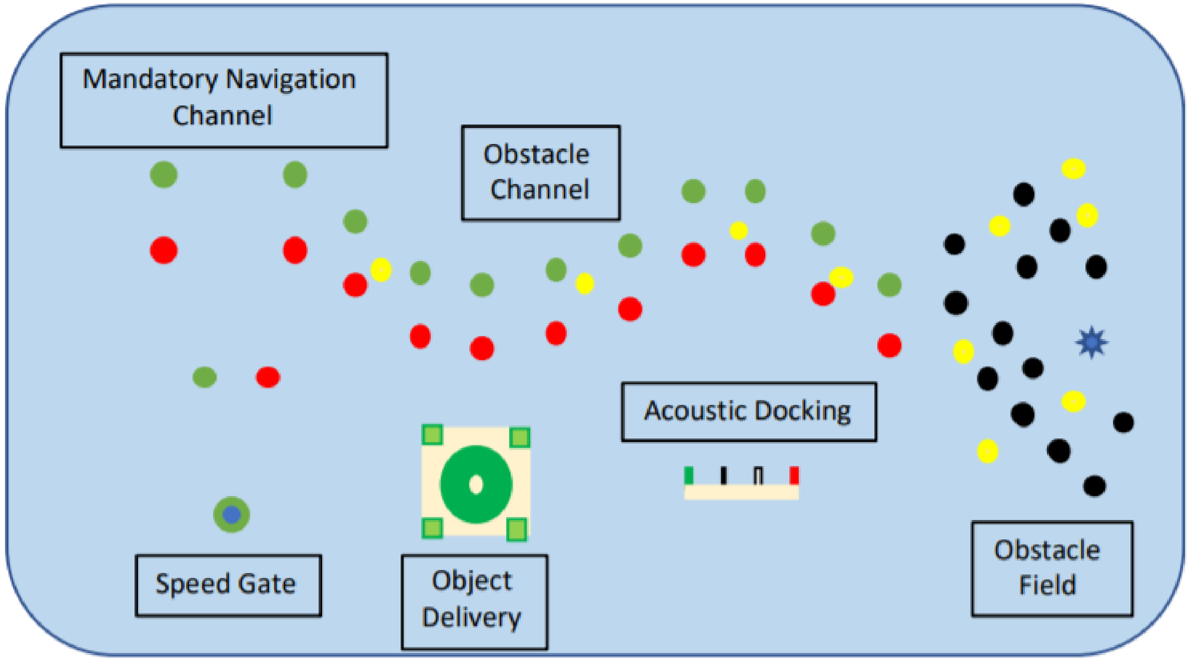


Figure 4: Sample course layout

<u>Environmental Considerations</u>:

- Freshwater lake
  - No tide
  - Minimal wave presence
  - Some wind present
- Rain or Shine performance

<u>Boat Functionality Considerations</u>:

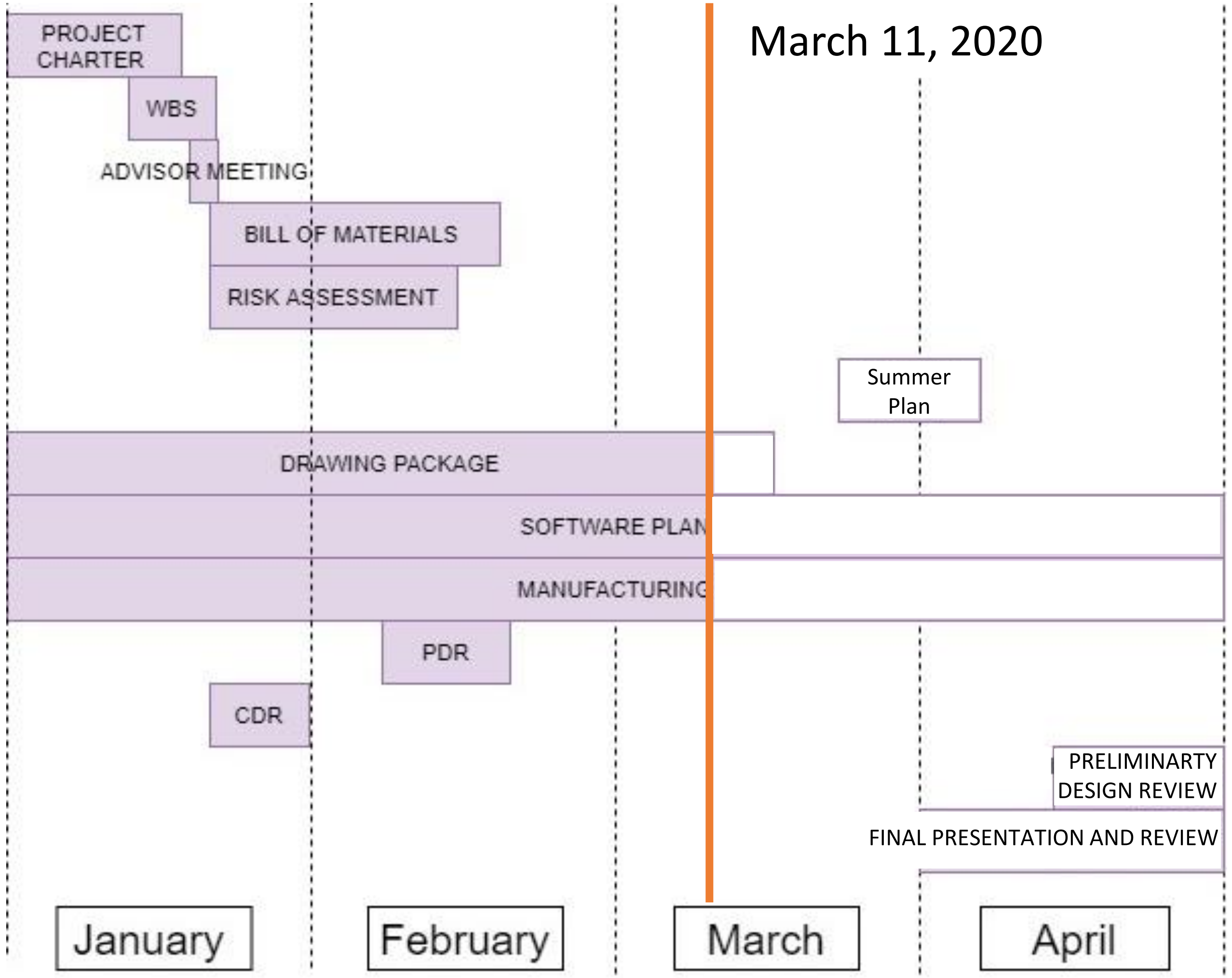
- Ability to navigate competition course
  - Speed Gate
  - Mandatory Navigation Channel
  - Obstacle Channel

Courtney Cumberland

Project Management

Toni Weaver

Schedule/Gant Chart



Toni Weaver

Senior Design Budget

Material	Amount Needed	Cost Per Unit	Total
Mold			**$66.00**
• Foam (.5” x 4’ x 8’) • 3M #77 Spray Glue • 2” Drywall Screws	2 sheets 3 cans 1 box	$15.00 /sheet $10.00 /can $ 6.00 /box	$30.00 $30.00 $ 6.00
Fiberglass • 6 ounce plain weave	20 yards	$8.15	**$163.00**
Resin	1 gallon	$90.00	**$90.00**
Hardware			**$146.00**
• Latches • Hatch supports • Hinges • Weather Stripping • Eyebolts • Green Rope	2 2 2 10 feet 4 15 feet	$20.00 $25.00 $10.00 $1.00/foot $4.00 $0.62 /foot	$40.00 $50.00 $20.00 $10.00 $16.00 $10.00
Tools / Supplies			**$100.00**
Brushes, Rollers, Tarp, etc.			
Miscellaneous			**$100.00**
		TOTAL:	**$665**

Toni Weaver

Total Competition Budget

Category	Total Needed	Have	Total remaining
Competition costs	**$12,499**	**$5,725**	**$6,773**
• Uniforms • Competition Stay			
Boat Component Cost	**$20,864**	**$18,334**	**$2,529**
• Thrusters • Computers • Batteries • Safety Switch • Visual response • GPS unit			
Boat Manufacturing Cost	**$665**	**$0**	**$665**
• Fiber Glass • Expoxy • 3M Glue • Foam • Latches • Fans			
Miscellaneous	**$1,167**	**$916**	**$250**
• Cart • Rc Unit • Soldering Kits			
Tools	**$1,278**	**$878**	**$400**
• Dremel • MultiMeter • Ifixit Kit • Wire Cutter and Stripper			
Total	**$36,473**	**$25,854**	**$10,591**

Toni Weaver

Design Criteria and Implementation

Brandon Bascetta

Design Criteria and Implementation

Last semester our team created an initial boat design using the proper engineering design method. This method was including, but not limited to:

- Customer Needs
- Functional Decomposition
- House of Quality

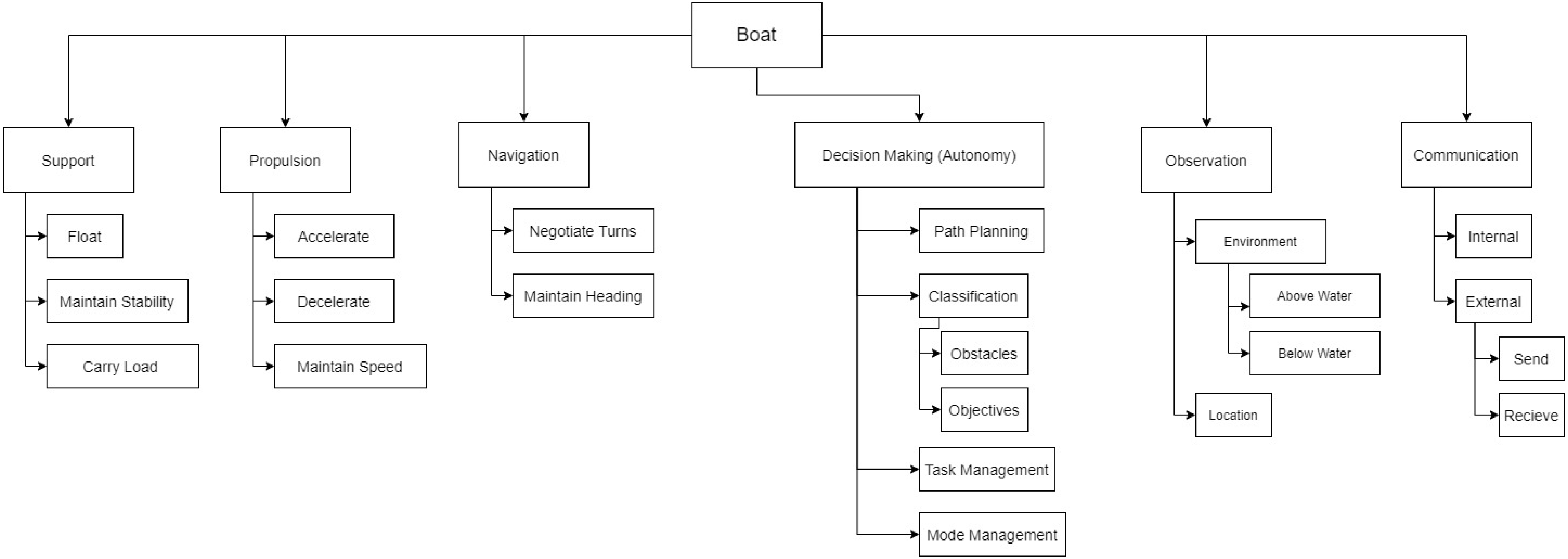
Brandon Bascetta

Customer Needs

Questions Asked	Need Statement
What features of the boat design are most important to you?	Provide adequate boat space for all components and enough space to work on.
Do you believe the boat should be modular, or an “all in one” design?	Able to easily change parts to the boat.
Given the required dimensions of 3 ft width, 6 ft length and 3 ft height, what features do you believe should be given the most priority/room in the boat?	Adequate space to work with components, air flow, and working space. Also, proper weight distributions.

Brandon Bascetta

Functional Decomposition



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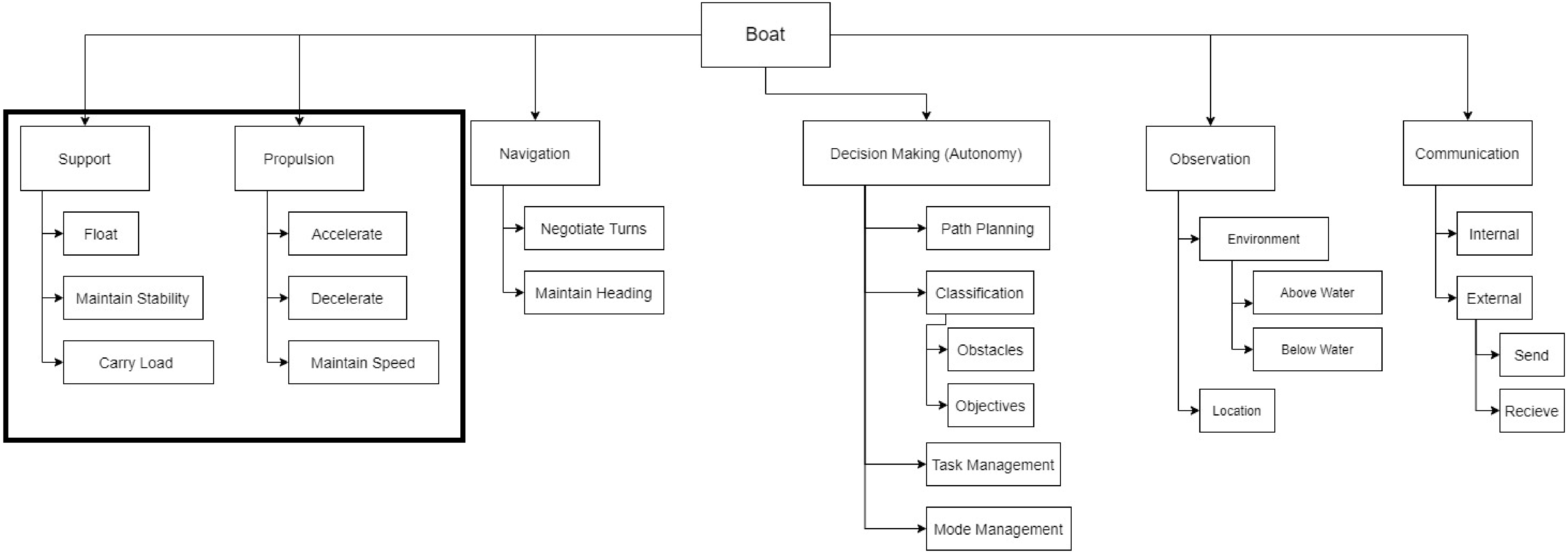
Functional Decomposition



Brandon Bascetta

Boat Design Inspirations: Mono-hull Vs. Catamaran

Brandon Bascetta

Boat Design Inspirations: Boston Fireboat

Brandon Bascetta

Concept Development

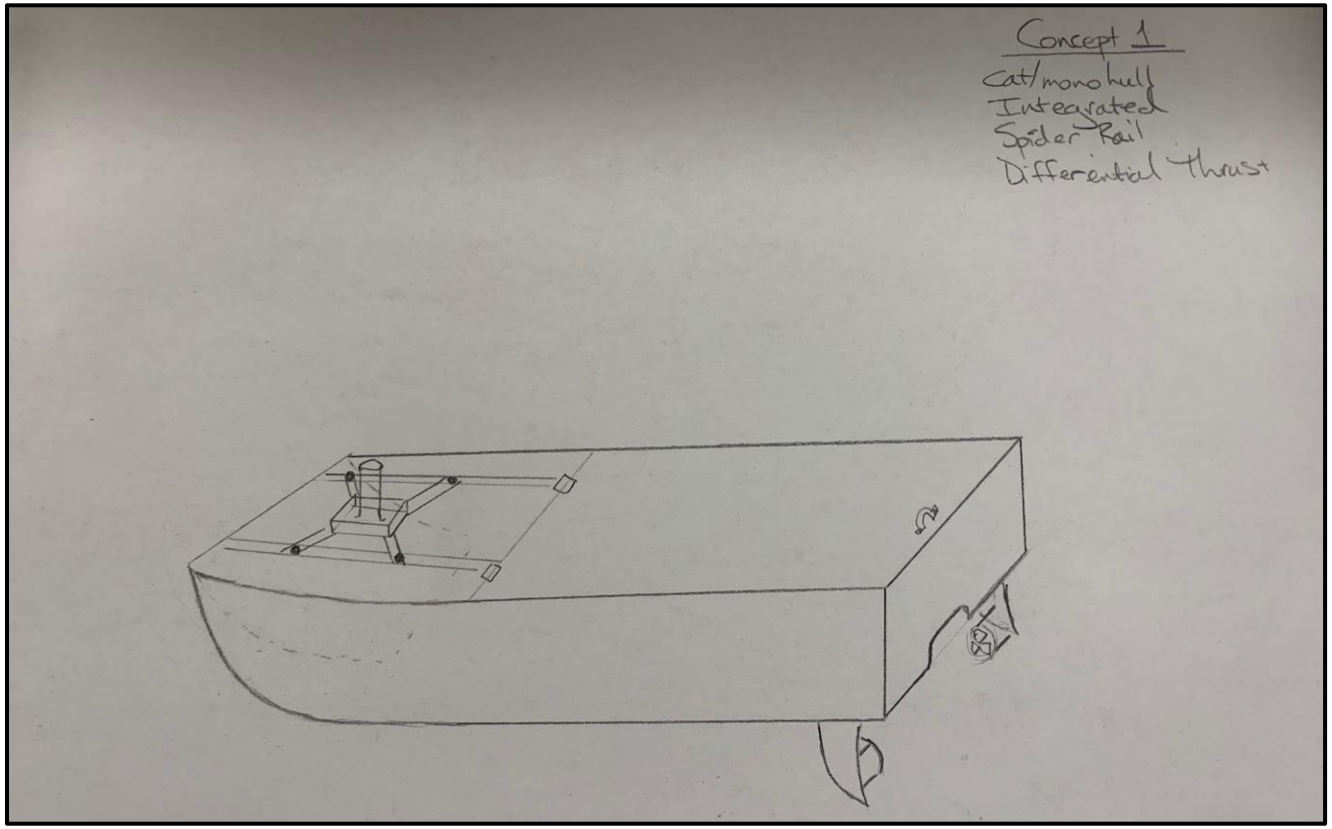
Hull	Super Structure (Material)	Propulsion	Sensor	Cooling System	Connection
Catamaran	Cardboard	Differential Thrus	Spider Rail	Fans(Active)	Rail System
Monohull	Tuberware	2 vector Thrust	Tree Stump	Vents (Passive)	Grenade Pin
Round	Pelican Box	4 Vector Thrust	Narwhal	Water Cooling	Snap Down
Trimaran	Carbon Fiber	rudder	Hole-y Board	Mineral Oil	Clam Shell (Hinge)
Hovercraft	Same Material	Sail	Tower of Terror		Convertable (Corvette)
	Wood				

	Conept Assemblies					
Concept 1	Cat/Mono	Same Material	Differential	Spider Rail	Active	N/a
Concept 2	Cat/Mono	Modular	Differential	Spider Rail	Active	Grenade Pins
Concept 3	Long Cat	Same Material	Differential	Spider Rail	Active	N/a
Concept 4	Long Cat	Modular	Differential	Spider Rail	Active	Snap Down

Brandon Bascetta

Concept Renderings: Concept 1

Concept 1:
- Mono Hull/Catamaran Hybrid
- Integrated Hull
- Differential Thrust
- Active Air Cooling
- “Spider Rail” Sensor Mount



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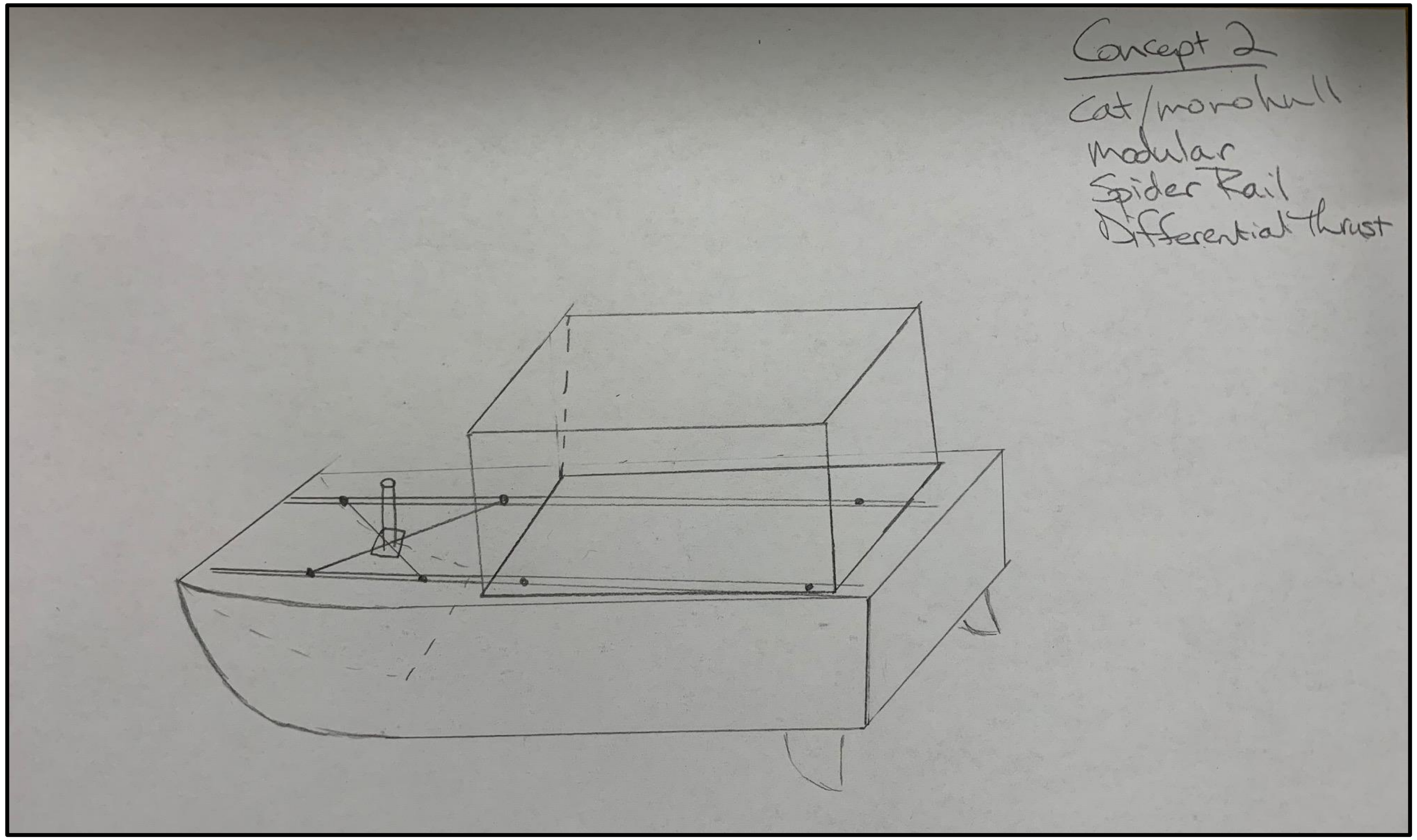
Concept Renderings: Concept 2

Concept 2:

- Mono Hull/Catamaran Hybrid
- Modular
- Differential Thrust
- Active Air Cooling
- "Spider Rail" Sensor Mount
- "Grenade Pin" Connection



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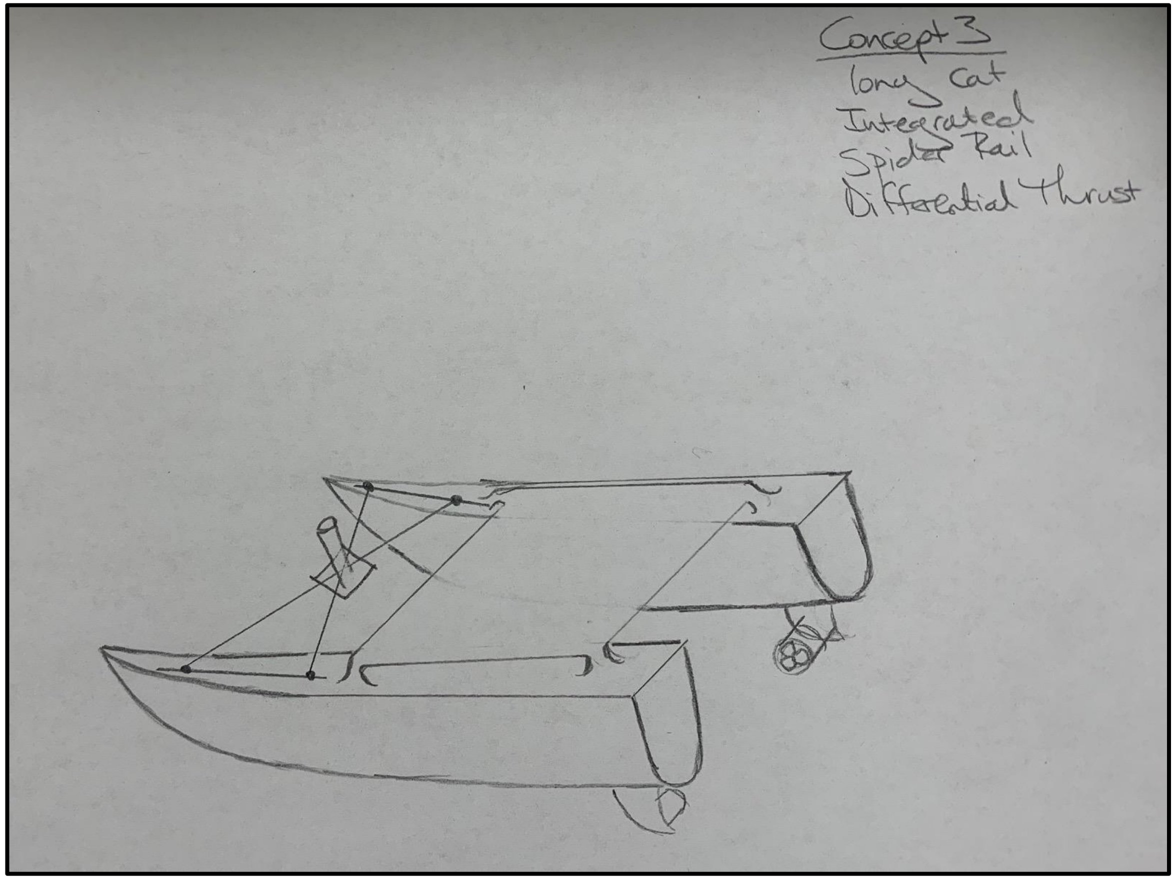
Concept Renderings: Concept 3

Concept 3:
- Long Catamaran Hull
- Integrated Hull
- Differential Thrust
- Active Air Cooling
- “Spider Rail” Sensor Mount



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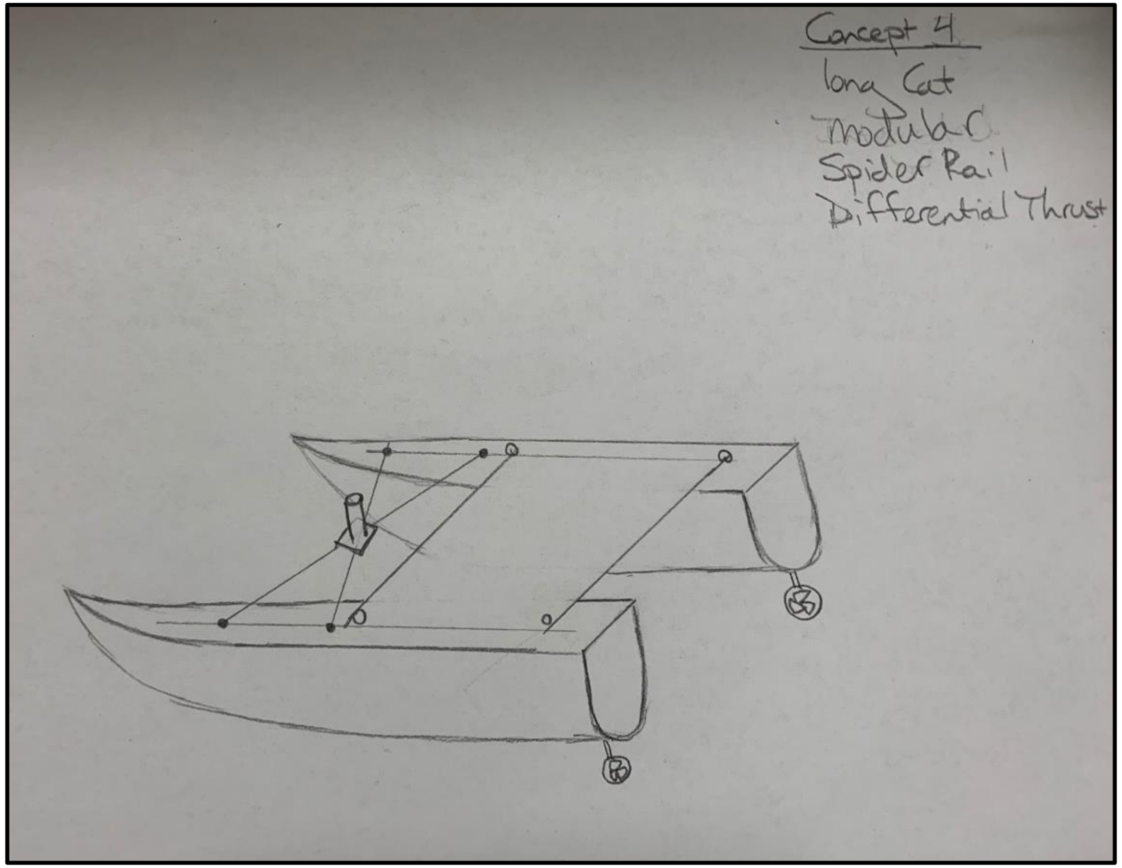
Concept Renderings: Concept 4

Concept 4:

- Long Catamaran Hull
- Modular
- Differential Thrust
- Active Air Cooling
- “Spider Rail” Sensor Mount
- “Grenade Pin” Connections



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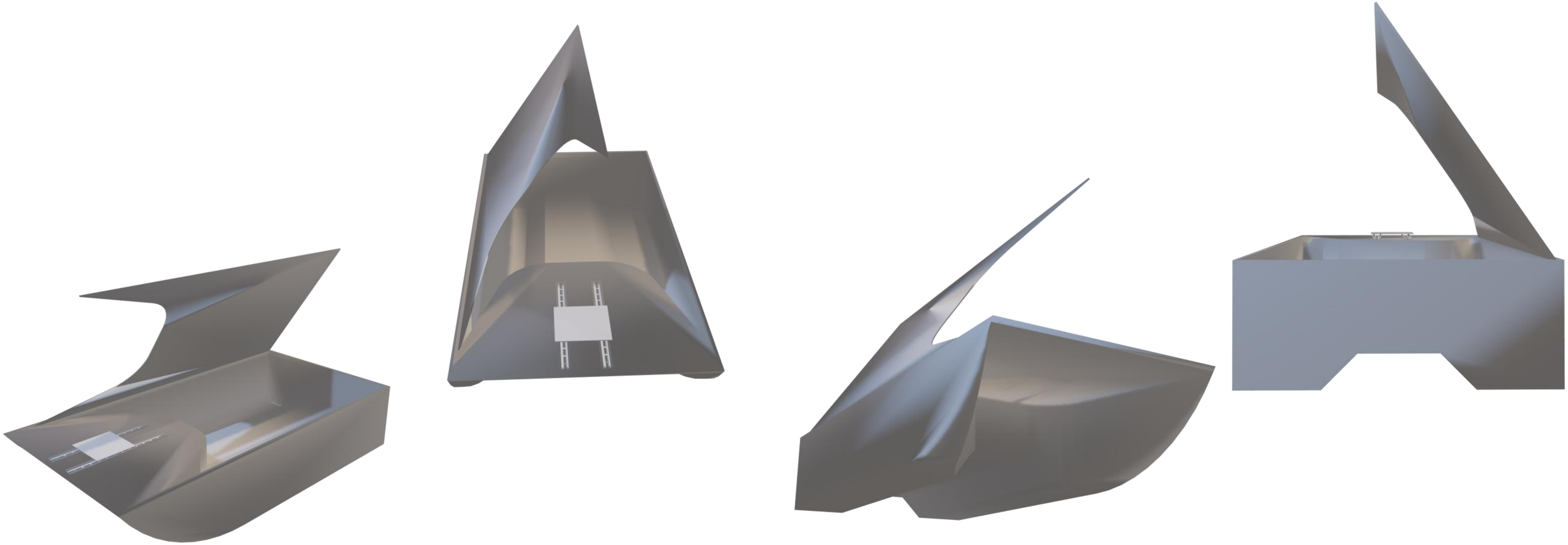
Concept Selection

Custoemer Requirements	Importance Weight Factor	Concept 1	Concept 2	Concept 3	Concept 4
Stability	5	3	3	3	3
Aesthetics	3	3	3	3	3
Maneuvaribility	6	1	1	3	3
Modularity	1	0	9	0	9
Deck Space	3	9	3	1	0
Manufacturability	1	3	3	9	9
Speed	2	3	3	1	1
Raw Score:	**189**	**66**	**57**	**56**	**62**

Concepts	
1	Monocat Integrated
2	Monocat Modular
3	Long Cat Integrated
4	Long Cat Modular

Brandon Bascetta

Concept Renderings: Higher Fidelity Design



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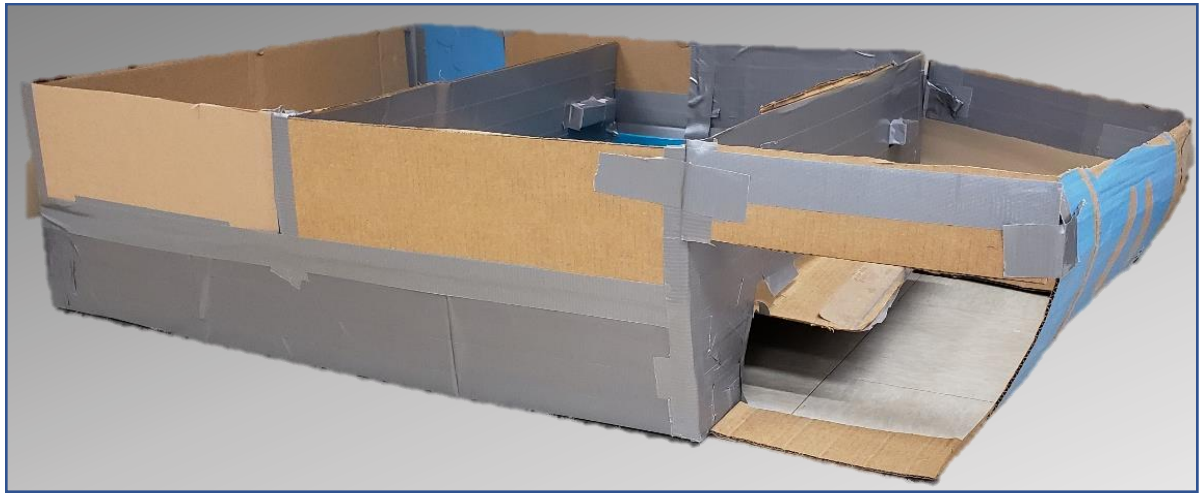
First Boat Design

- The original dimensions were 32” x 60”
- Physical boat was modeled out of cardboard



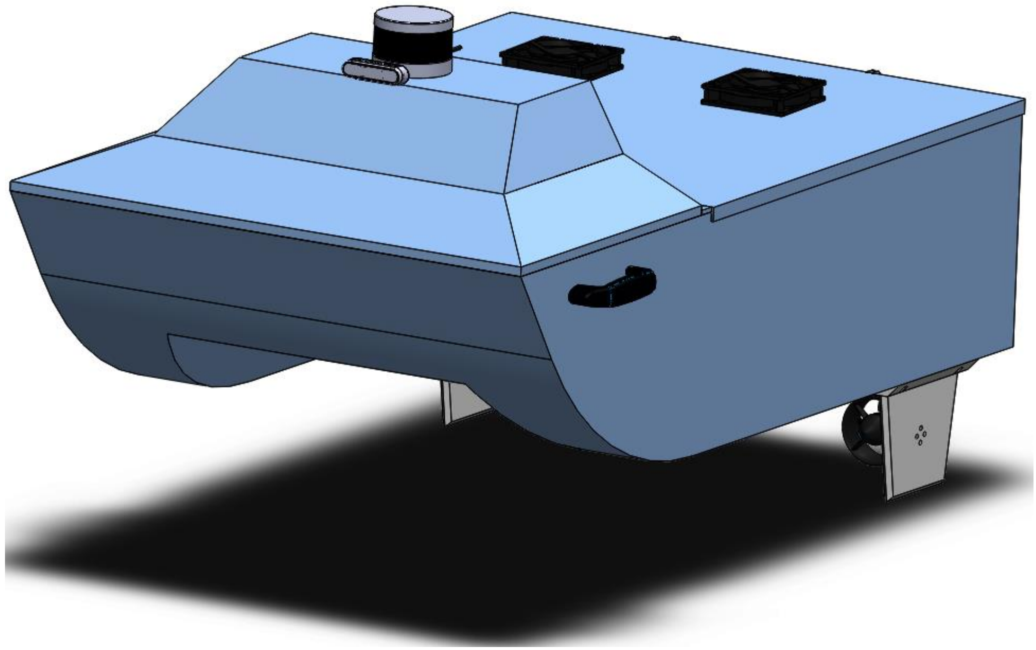
Brandon Bascetta

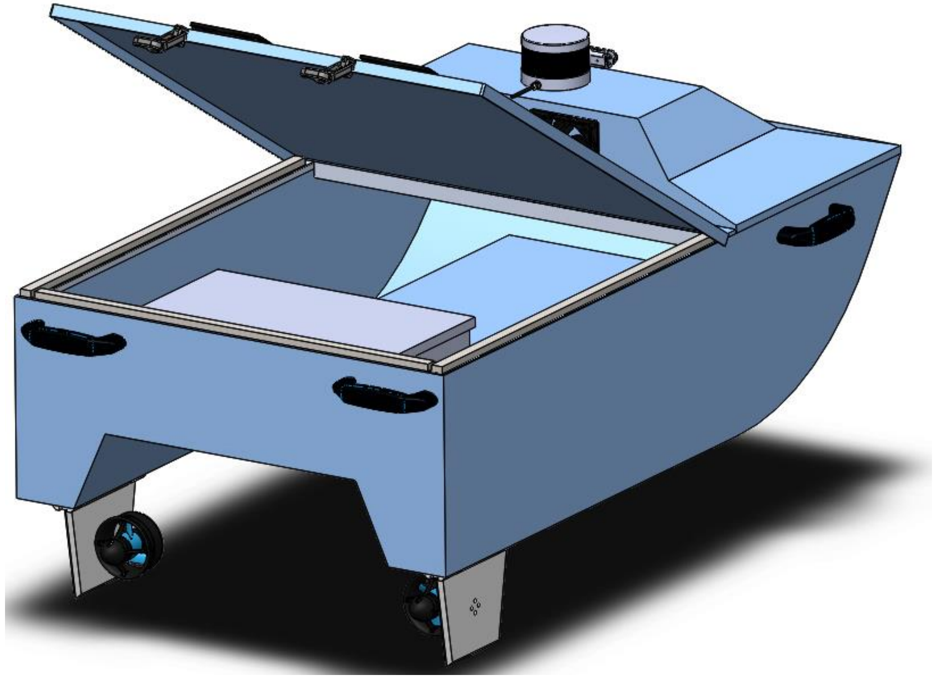
Second Boat Design

- It was decided that the first boat design was too large.
- Physical mockups of the sensors/components being used to create a layout the space needed.
- The boat was then reduced to 30” x 50”

Brandon Bascetta

Final Boat Design





Brandon Bascetta

Boat Manufacturing Plan

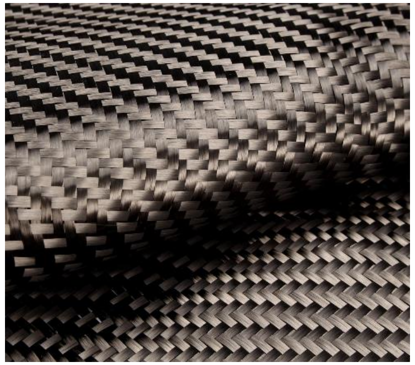
Courtney Cumberland

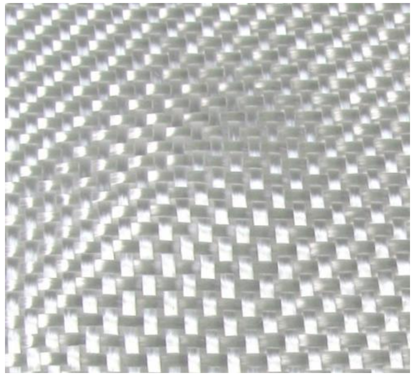
Material Selection

Material Choices:

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

Composites


Carbon Fiber


Fiberglass


Kevlar Fabric

Courtney Cumberland

Selected Material-Primary

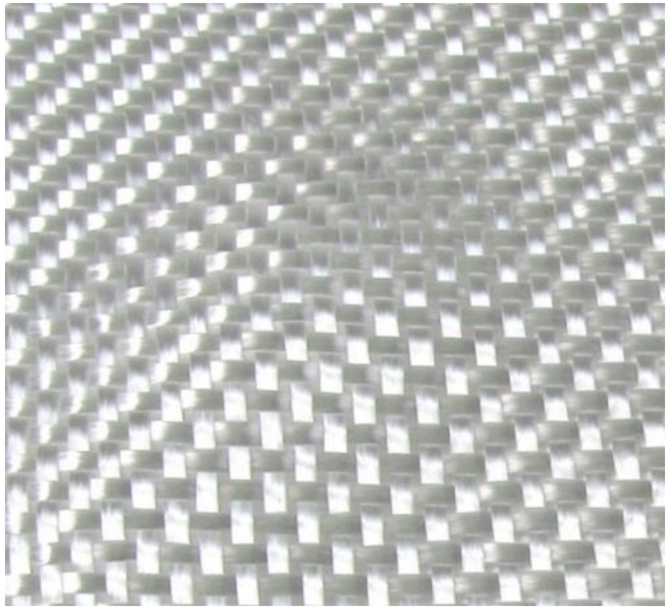
6 ounce Plain-Weave E-glass Fiberglass!!

Description:

- Weight : 6 oz per yd^2
- Thickness: 0.0093”
- Plain-Weave: 1 over-1 under

Reasons:

- Low Cost
- Manufacturability
- Anti-Corrosive
- Strength to weight ratio



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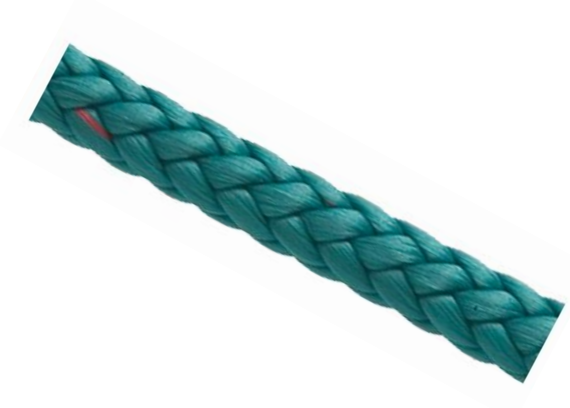
Selected Material-Secondary

Epoxy Resin System

Lid Latches



Green Harness Line

Handles

Courtney Cumberland

Manufacturing Plan

Manufacturing of the boat will follow the following steps:

1. Constructing molds for boat using foam
2. Testing mold for buoyancy
3. Applying a releasing agent over molds
4. Laying up fiberglass on top of molds using a vacuum bag process including sanding
5. Removing fiber glass boat parts from foam molds
6. Painting fiber glass hull

HPMI HIGH-PERFORMANCE MATERIALS INSTITUTE

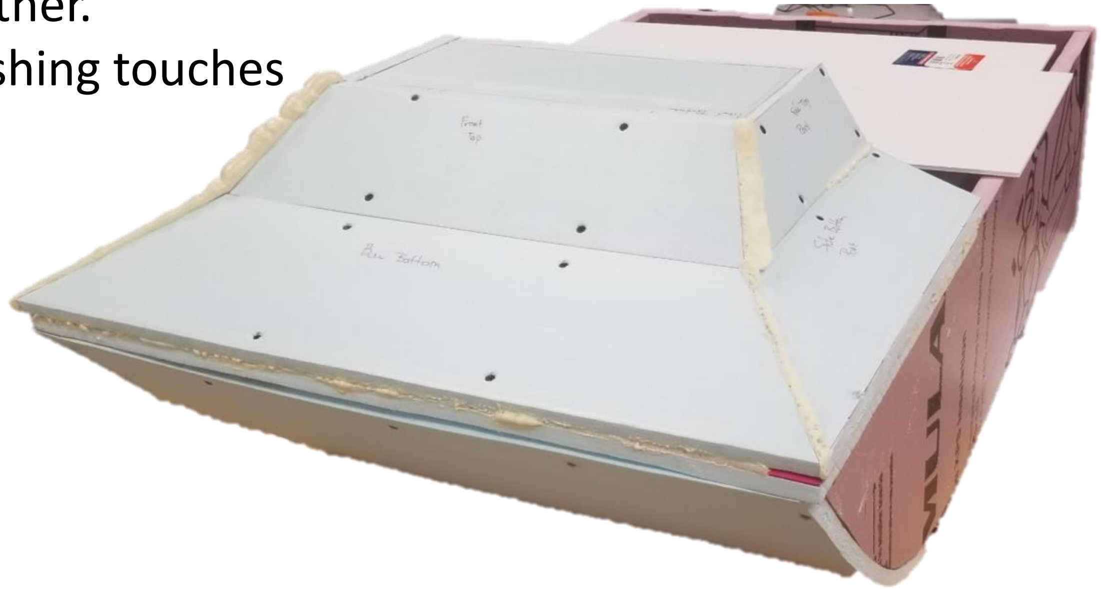
Tallahassee FSU High Performance Materials Institute will be assisting in boat manufacturing technique and procedure.

Courtney Cumberland

Manufacturing Plan

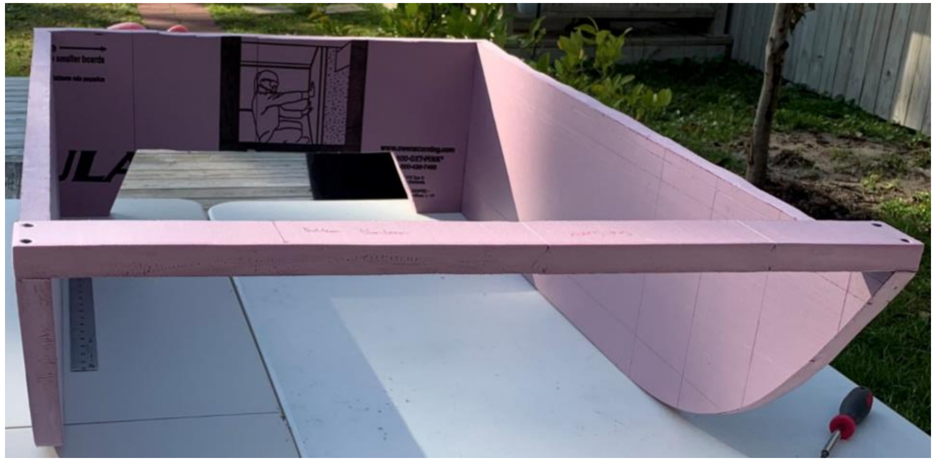
<u>Mold Construction</u>:

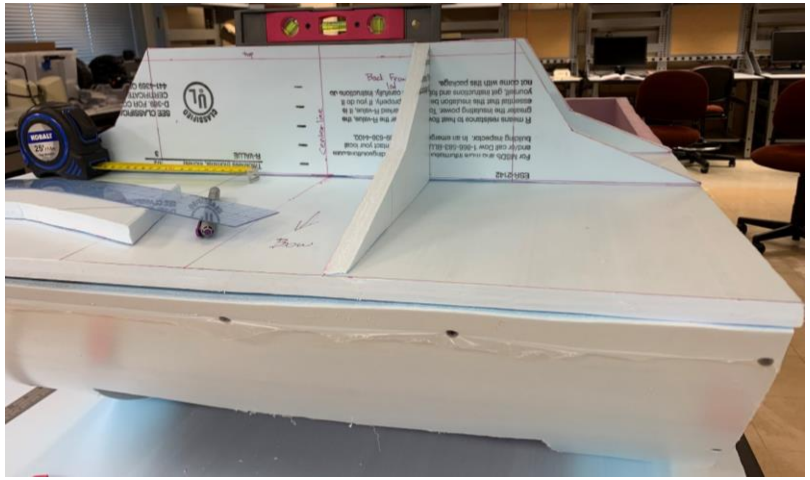
- Creating a mold is necessary for fiberglass boat construction
- 1” thick foam and ½” foam was used
- Patterns were created from measurements taken from the Solidworks drawings
- 2” drywall screws are used to secure pieces together.
- Sanded spray foam and packing tape are the finishing touches



Courtney Cumberland

Boat Mold Manufacturing Progression





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Manufacturing

Vacuum Bagging

Removes air voids as well as excess epoxy thus increasing strength to weight ratio

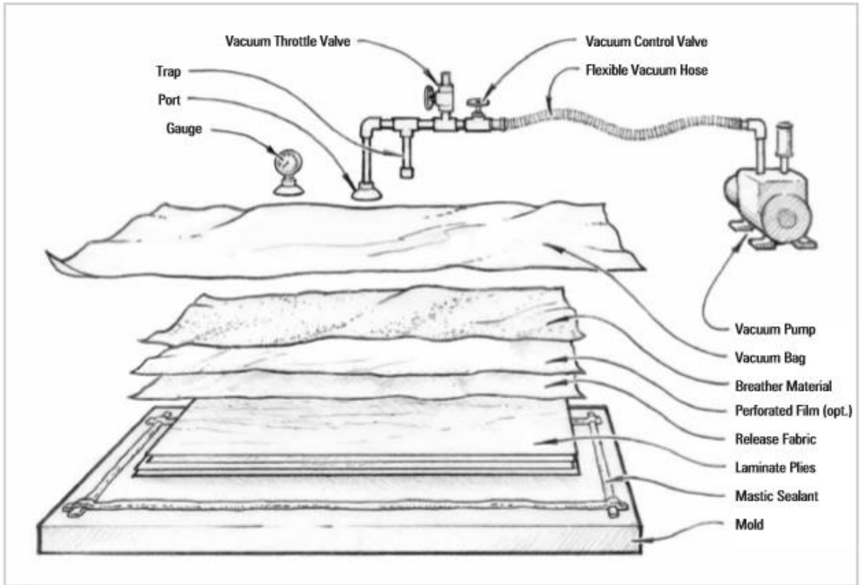

Figure 2-1 *Typical components of a vacuum bagging system.*

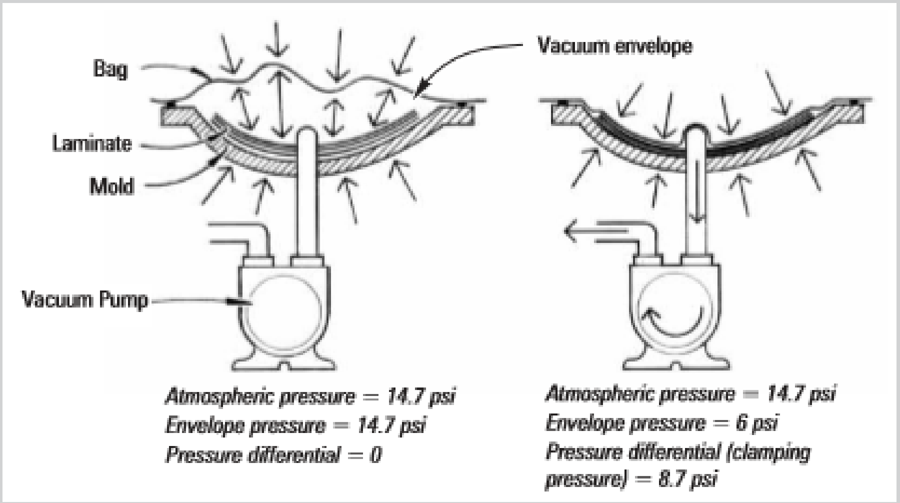

Figure 1-1 *A typical vacuum bagging lay-up before and after vacuum is applied.*

https://www.westsystem.com/wp-content/uploads/VacuumBag-7th-Ed.pdf

Courtney Cumberland

Current Project Status and Next Steps

Toni Weaver

Current Project Status: Hardware

As of today, the following accomplishments have been made towards the Manufacturing of the boat:

- Boat Design Finished
- Boat Mold Made
- Manufacturing plan set
- Budget organized

Toni Weaver

Current Project Status: Software

As of today, the following accomplishments have been made towards the Software:

- Motor Mixing Done
- Rc Control done
- Safety System Implemented

Toni Weaver

Next Steps…

- Finalize manufacturing drawings
- Procure Materials
- Test boat hull
- Install sensors

- Fine tuning of motor mixing
- Complete basic waypoint tasking

Toni Weaver