Design and Development of an Autonomous Underwater Vehicle

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Background

The 19th Annual International Robosub Competition

- Advance development of AUV's
- Perform realistic missions
- Saltwater environment

Competition Challenges

- Interact with color buoys
- Pass over an obstacle
- Drop markers
- Fire torpedoes through target
- Grab and move an object
- Travel toward pinger

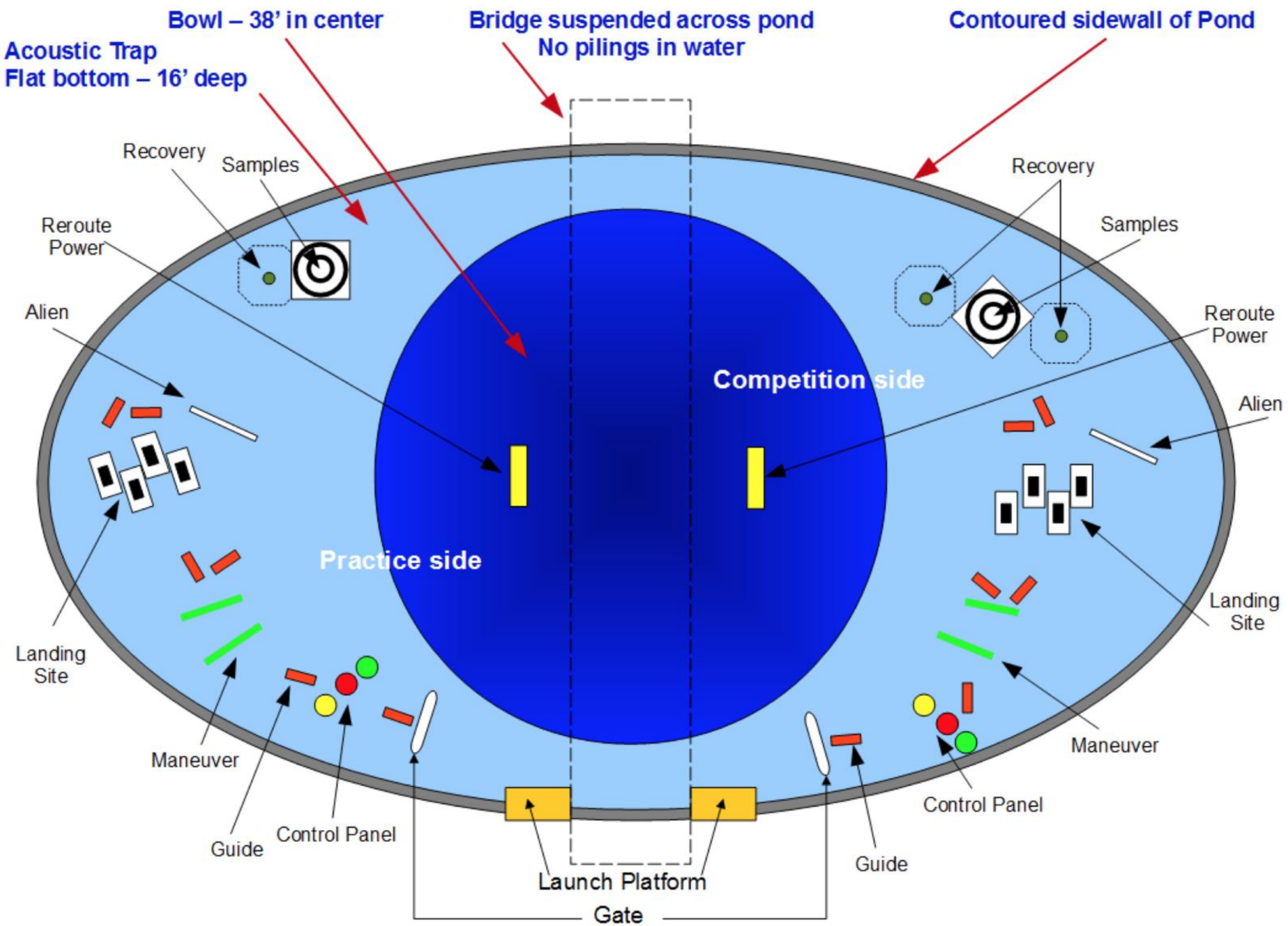


Figure 1: Schematic of competition pool's obstacles in San Diego, California

Background

The Current AUV

- Designed and Built in 2013
- Weighs about 120 lbf (apparently)
  - Information given from 2015 senior design team
  - Contains 22.5 lbf in weights within the hull

- Components
  - 6 Seabotics thrusters
  - Zotac
  - Arduino Mega and Uno
  - 3 Motor Controllers
  - an IMU
  - A Breadboard
  - Weights
  - 2 Cameras

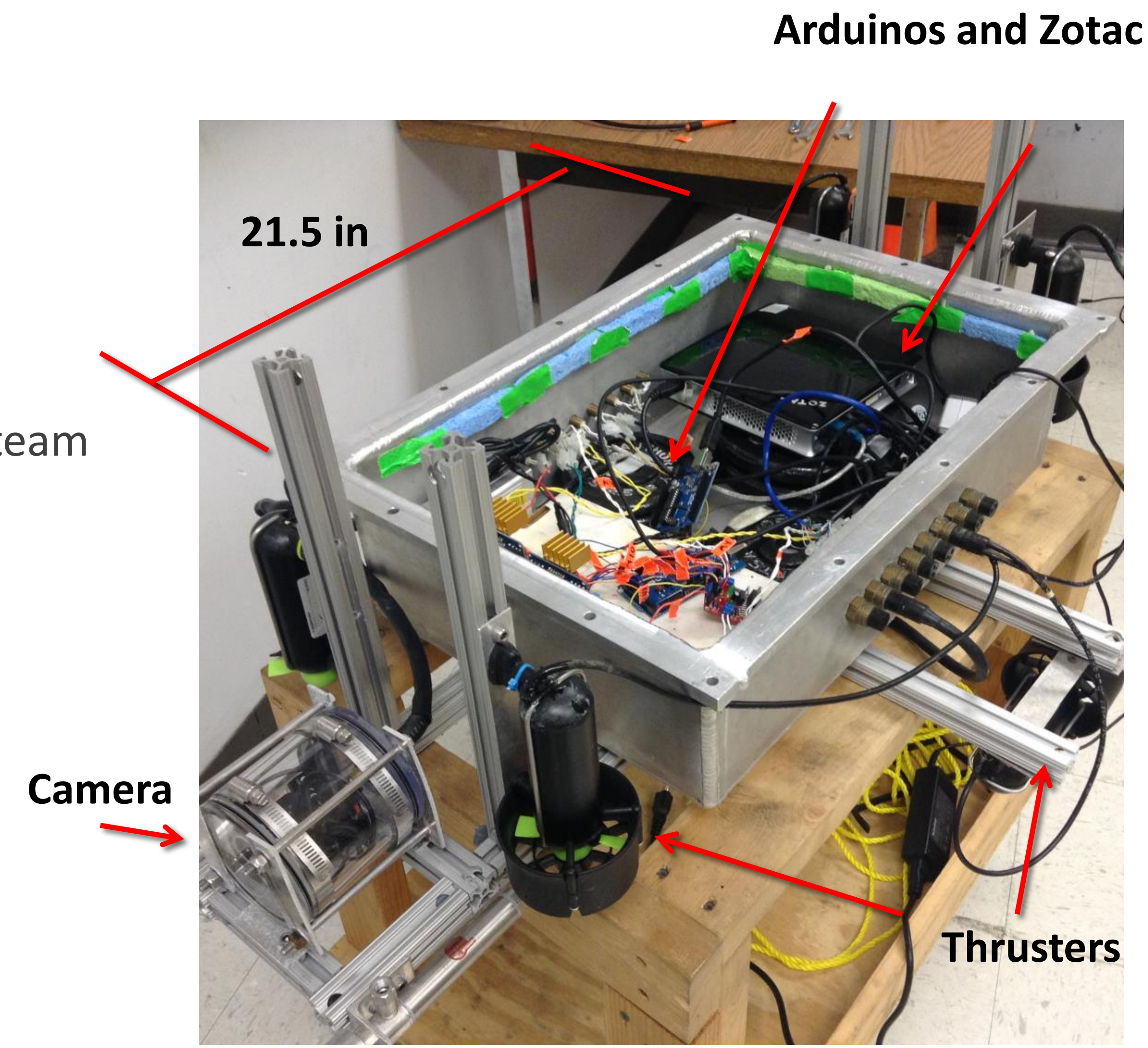


Figure 2: 2015 Robosub

Current Team Organization

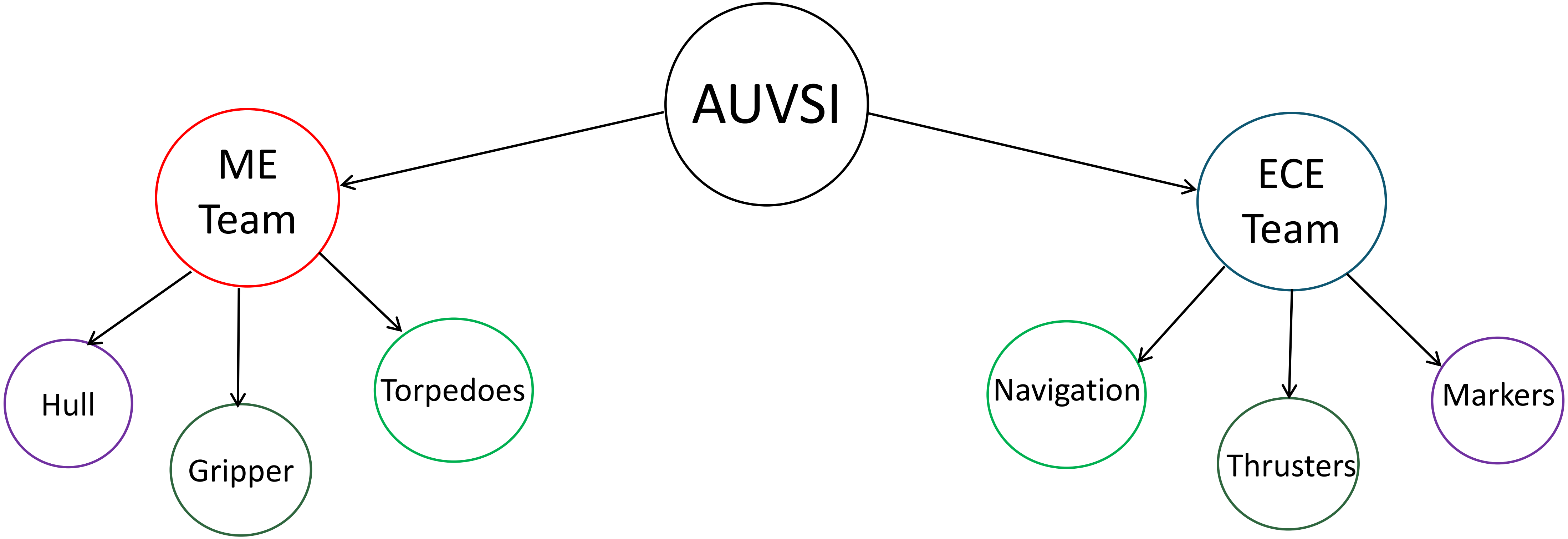


Figure 3: Team Management

House of Quality

Legend:

Correlation

- 1: Low
- 3: Medium
- 9: High

EC's of High Importance:

1. Sensing
2. Electronics Housing
3. Gripper Mechanism

		Engineering Characteristics									
Units		ft^3	lbf	lbf	N/A	lbf	N/A	N/A	N/A	N/A	N/A
Customer Requirements	**Importance Weight Factor**	**Dimensions**	**Buoyancy**	**Weight**	**Material**	**Thrust**	**Sensing**	**Frame**	**Electronics Housing**	**Torpedo Propulsion system**	**Gripper mechanism**
Cost - $2000 budget	5	1			1	1	9		3		1
Accessablity - easy to access components	4	3		3				3	9		
dimensions do not exceed 6x3x3 feet	3	9	9	9				3	3		3
Durability	4				9			3	3	1	1
Shoot a target with torpedoes	4						3	3		9	
Place markers in bins	4						3				9
Waterproof	5				3			1	9		
Detect frequencies between 20-45kHz	5						9				
Navigation through obstacles	5	3	3	1		9	9	1	1		
Do not harm testers	5			3	1	1	1	1	3	3	3
Raw Score		**59**	**42**	**59**	**61**	**55**	**164**	**60**	**137**	**55**	**69**
Relative Weight %		**8%**	**6%**	**8%**	**8%**	**7%**	**22%**	**8%**	**18%**	**7%**	**9%**
Rank Order							**1**		**2**		**3**

Table 1: House of Quality Matrix

Project Objectives

ME Lead Objectives

- Hull
  - weight, volume, heat dissipation, alternate designs
- Torpedoes
  - design torpedoes, firing mechanism
- Gripper
  - design claw, attachment

ECE Lead Objectives

- Navigation
  - thruster, depth control
- Image Processing
  - orientation, identification

Tests in Action

- Buoyancy and Leak Testing at Morcom Aquatics Center 10/16/15
- Determined
  - Weight = 83.5 lbf
  - Volume = 1.563 ft^3
- Buoyancy Force
  - Calculated: 100 lbf
  - Actual: (98-101.5) lbf
- Leaks
  - Dry own to 13’ 2”
- Conclusion of Tests
  - Cut Volume
  - Reduce weight

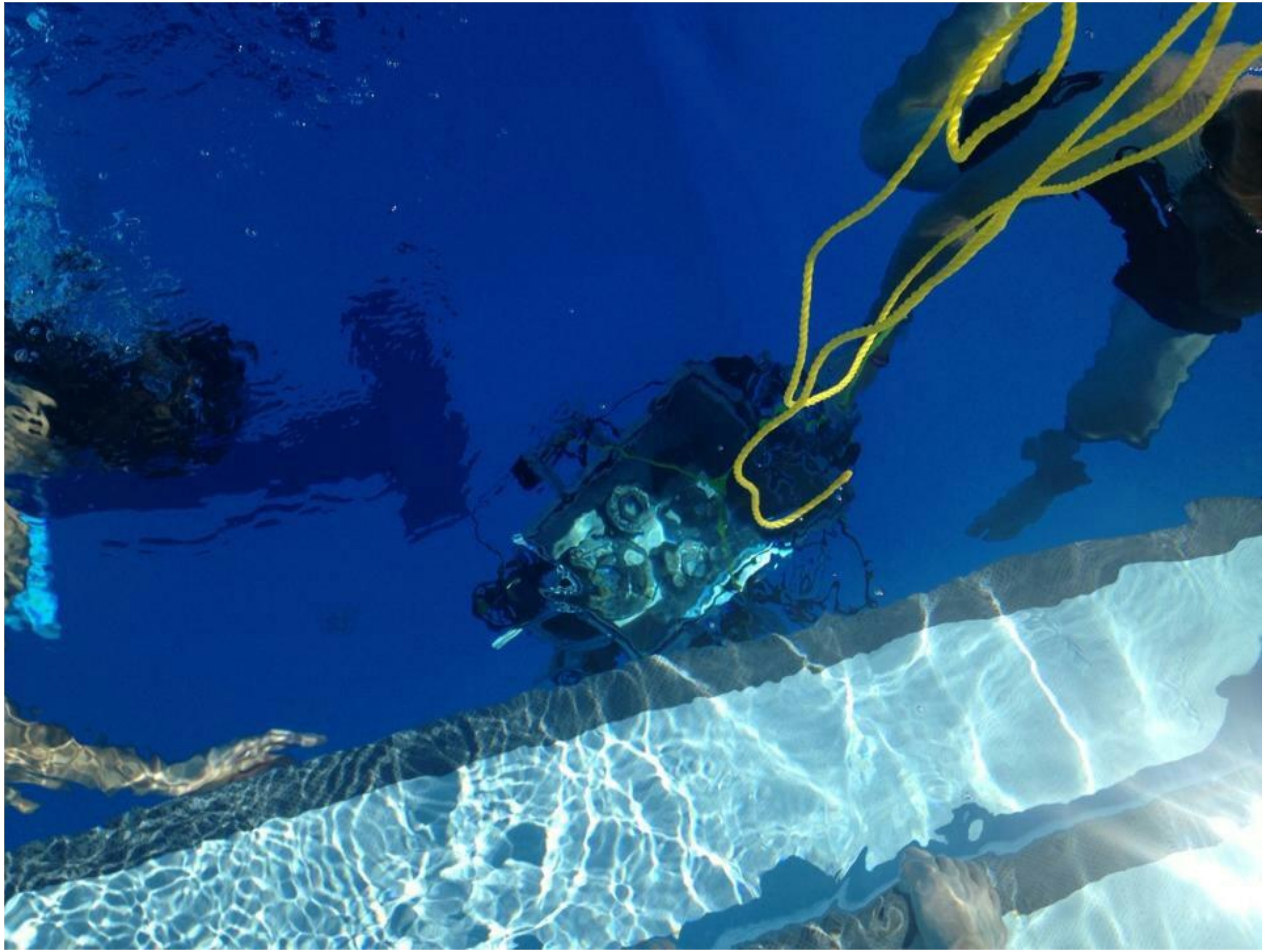
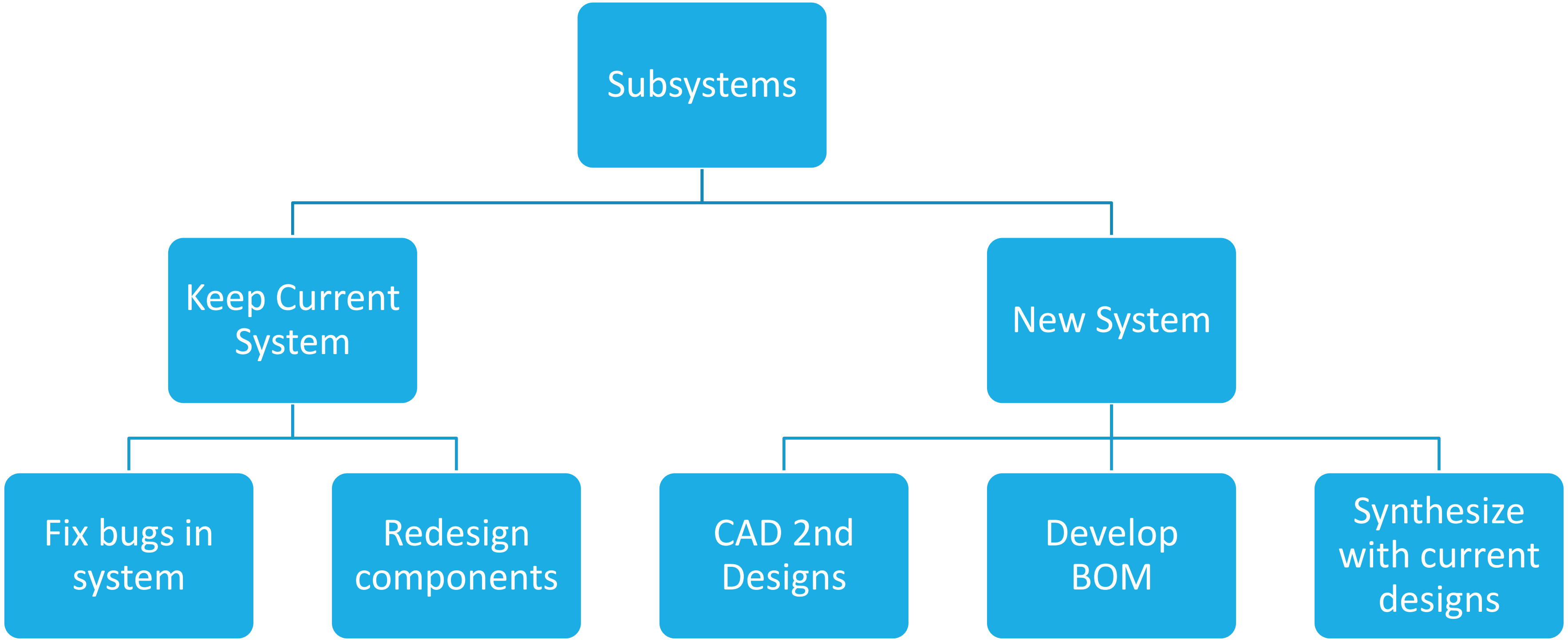
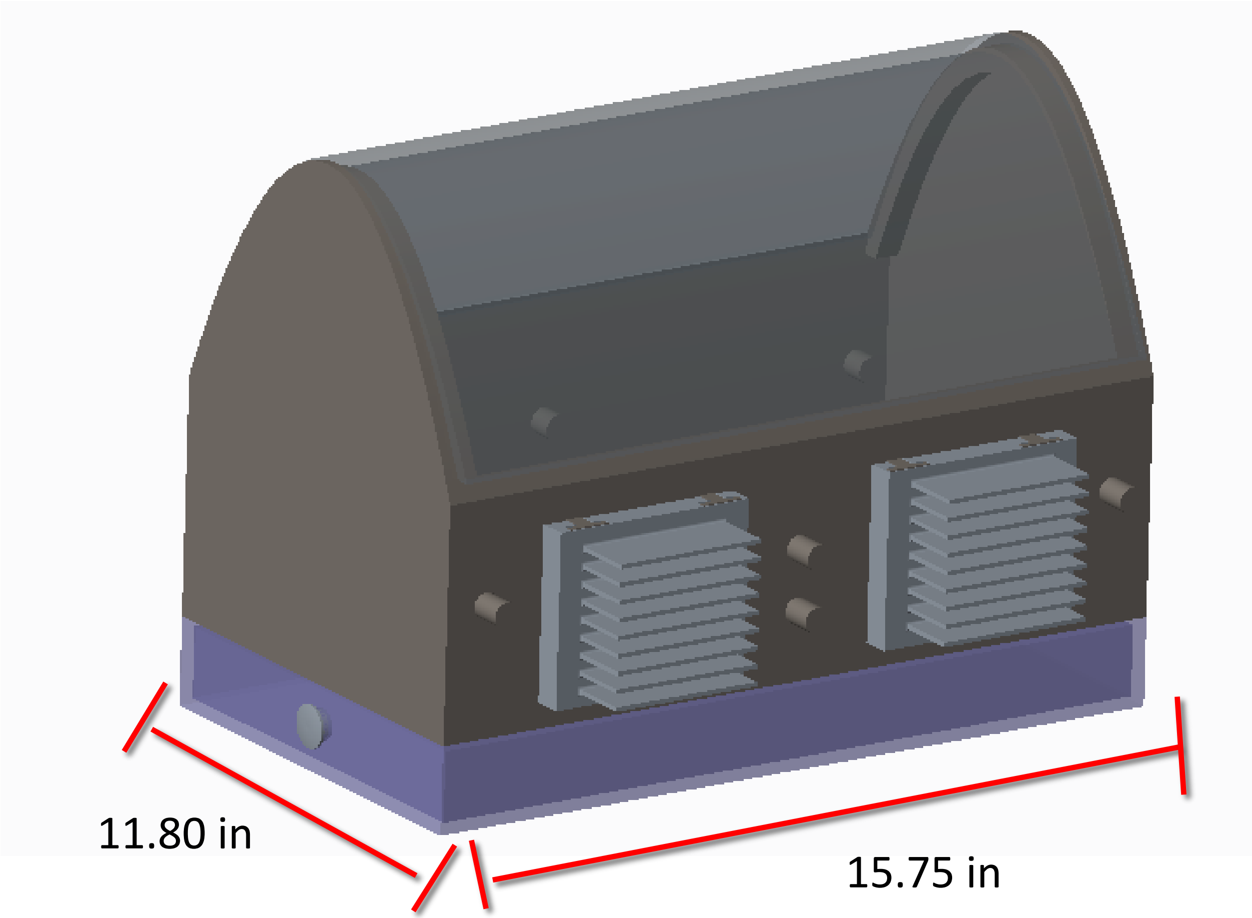


Figure 4: Testing of Hull for Buoyancy/Weight calculations and Leakage

Course of Action



Potential Hull Changes #1



Features

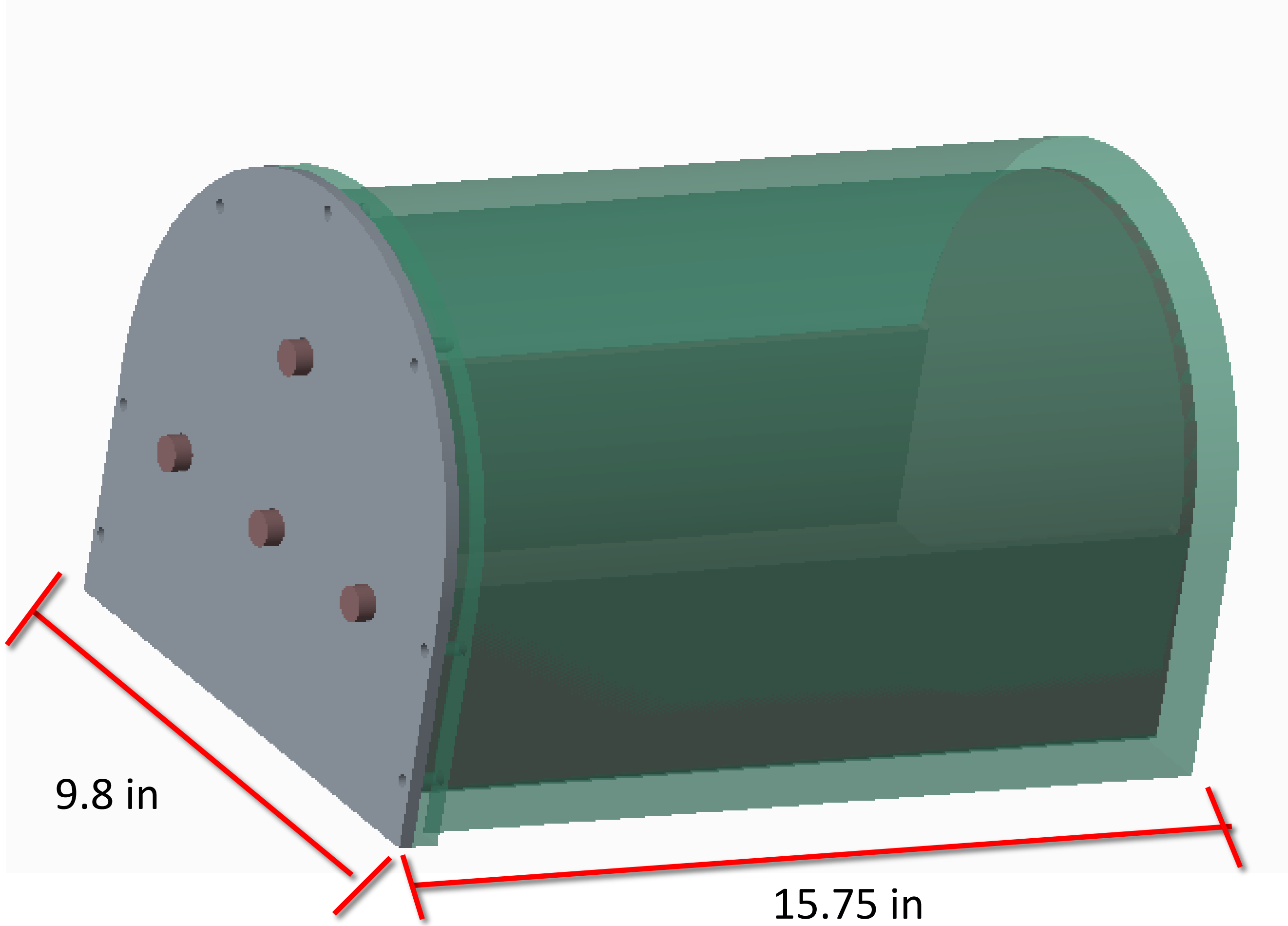
- Heat transfer fins following fluid flow
- Ballast tank for buoyancy control
- Clear rounded lid

Specs

- Volume: 0.6 ft^3

Figure 5: Hull Concept Design 1

Potential Hull Changes #2



Features

- Easy access sliding mechanism for sub internals
- Smaller waterproofing sealing area
- Fewer screws for faster electronics access

Specs

- Volume: 0.57 ft^3

Figure 6: Hull Concept Design 2

Torpedoes

- Previous year's 3D printed design
- Built of ABS plastic, internal metal rod, and embedded magnet

- Recreated previously designed Torpedo in CAD
- Performing Calculations and experimentation to determine if redesign is necessary

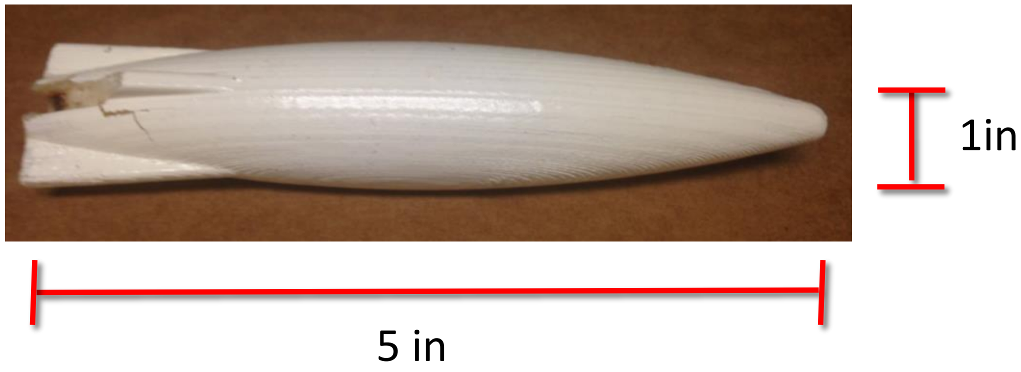


Figure 7: Previously Designed Torpedo

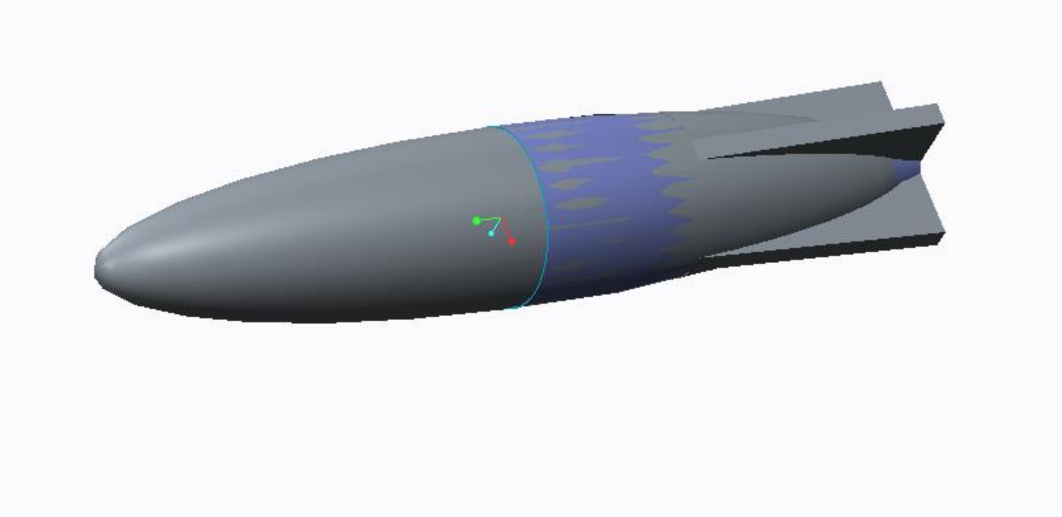


Figure 8: CAD Designed Torpedo

Gripper

- Interfaces with lower camera
- Runs off of compressed air (force holds object in claw)
- Adjustable heads
  - Head pinches object (shown at the right)
- Protruding 17 inches below the hull due to lower camera placement

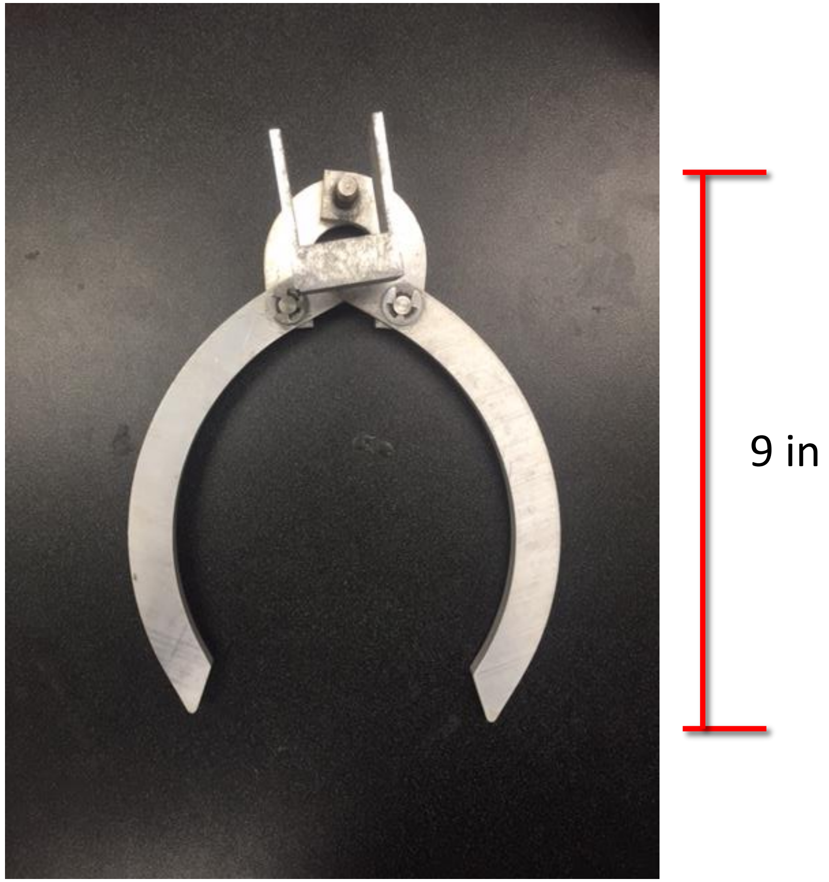


Figure 9: Gripper Mechanism

Electronics

Zotac
- Main CPU
- Processes images from camera
- Interfaces with Arduino UNO and Arduino MEGA
- Interfacing with additional microcontroller

Arduino MEGA
- Microprocessor that controls all 6 thrusters
- Primary controller
- IMU

Addition of another microcontroller if necessary
- Control gripper and torpedoes
- servo controlled valves or pre packaged control valve
- Potentially replace unrefined breadboard

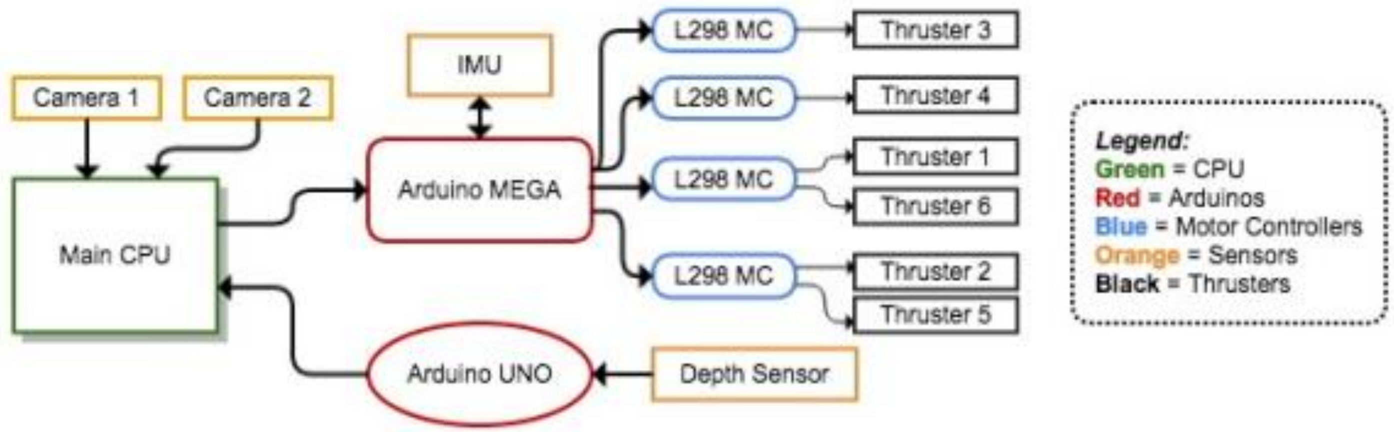


Figure 10: Schematic of electronics

Gantt Chart for Fall 2015

	Task Name	Duration	Start	Finish
1	**Troubleshoot Subsystems**	**26 days**	**Mon 10/12/15**	**Fri 11/13/15**
2	**Image processing**	**5.2 wks**	**Mon 10/12/15**	**Fri 11/13/15**
3	IP (color ID)	1 wk	Mon 10/12/15	Fri 10/16/15
	IP (shape ID)	2 wks	Mon 10/19/15	Thu 10/29/15
	IP (Orientation ID)	1 wk	Fri 10/30/15	Thu 11/5/15
6	IP (Debugging)	1 wk	Fri 11/6/15	Thu 11/12/15
7	**Hull**	**5.2 wks**	**Mon 10/12/15**	**Fri 11/13/15**
8	Hull - CAD current sub	3 days	Mon 10/12/15	Wed 10/14/15
9	Hull - Math/Testing	1 wk	Thu 10/15/15	Wed 10/21/15
10	Hull - initial designs	8 days	Mon 10/12/15	Wed 10/21/15
11	Hull - CAD design choice	1 wk	Thu 10/22/15	Tue 10/27/15
12	Hull - materials/order parts	3 days	Wed 10/28/15	Fri 10/30/15
13	Hull - procurement	1 wk	Mon 11/2/15	Fri 11/6/15
14	Hull - assembly	5 days	Mon 11/9/15	Fri 11/13/15
15	**Navigation**	**3.2 wks**	**Mon 10/12/15**	**Fri 10/30/15**
16	Navigation - debug thrusters	1 wk	Mon 10/12/15	Fri 10/16/15
17	Navigation - IMU control	1 wk	Mon 10/12/15	Fri 10/16/15
18	Navigation - depth sensor	1 wk	Mon 10/19/15	Fri 10/23/15
19	Navigation - Debug	1 wk	Sat 10/24/15	Thu 10/29/15
20	Submerge the AUV	2 days	Fri 10/30/15	Sun 11/1/15
21	**Components**	**14 days**	**Fri 11/13/15**	**Mon 11/30/15**
22	Claw	14 days	Fri 11/13/15	Mon 11/30/15
23	Torpedoes	14 days	Fri 11/13/15	Mon 11/30/15
24	Re-Submerge	3 days	Tue 12/1/15	Thu 12/3/15
25	Debug Errors	5 days	Fri 12/4/15	Wed 12/9/15
26	Final Submersion	3 days	Thu 12/10/15	Mon 12/14/15

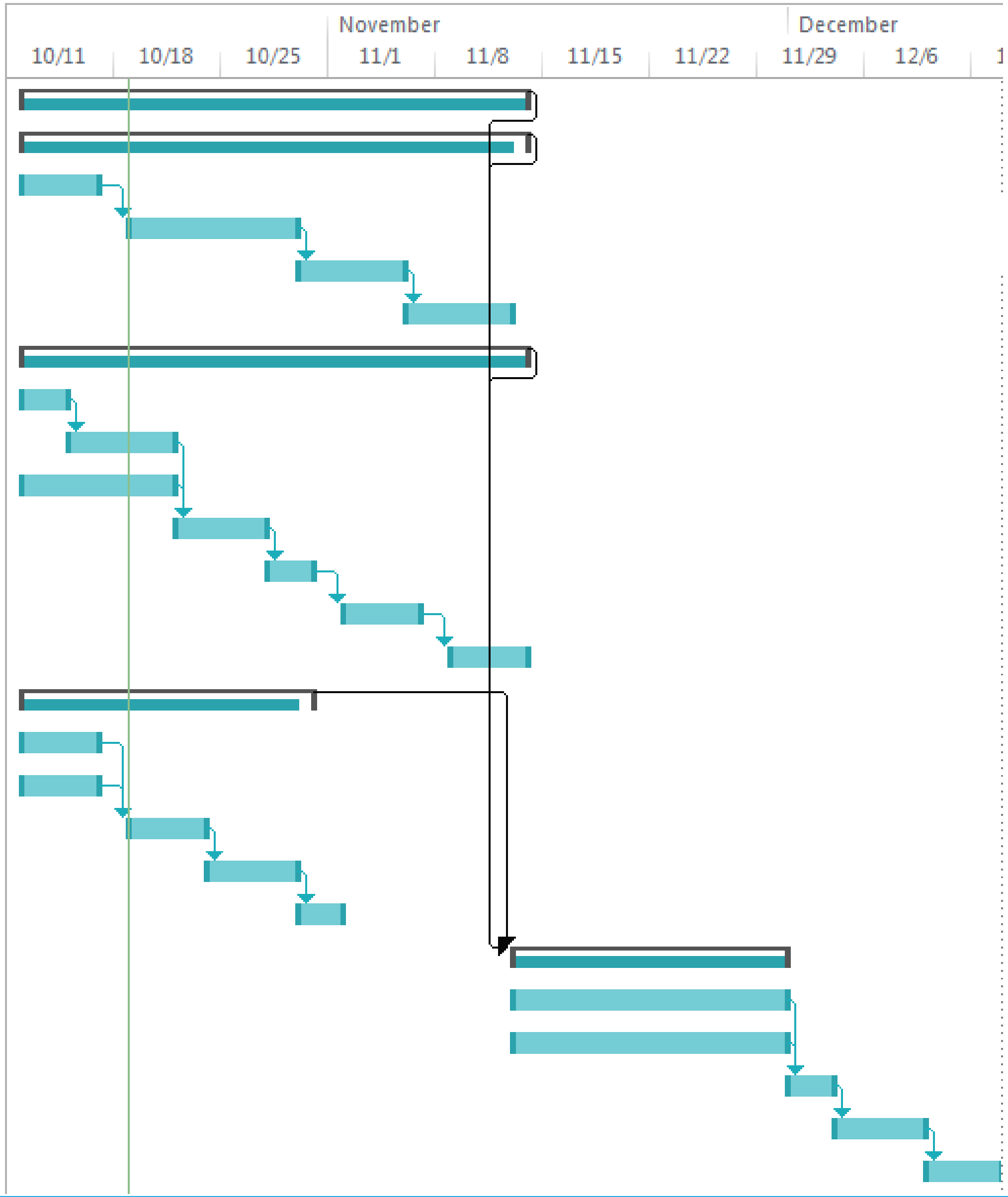


Figure 11: Gantt Chart for Fall Semester

Challenges and Risks

RISKS

- The biggest risk is water damage to the electronics
- Electronics overheating
- Safety (electricity, weight)

CHALLENGES

- Time
- Automation of the sub
- Integration of the subsystems
- Organization and efficiency of a 10 member team

Conclusion

Last year's design has been analyzed and the hull was tested

- No leaks, buoyancy to weight needs optimization
- Current hull will be used for subsystem testing

Development of sub-system designed to complete competition tasks

Integration of ME and ECE tasks

- Transition from mechanical design to autonomous movement

References

1. *"The Competition of Competition Rules." The New Systems Competition (2003): 178-206. Robosub.org*. TRANSDEC Facility. Web.
2. *"Appendix A: MemWorX User Manual." Peters/Membrane Process Design Membrane Process Design Using Residue Curve Maps* (2011): 183-99. Web.