Design and Development of an Autonomous Underwater Vehicle

Midterm II Presentation
Team 23
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Presentation Outline

- Review of Background Information
  - Competition: constraints and challenges
  - Project: what we inherited
- The Project
  - Past: tests
  - Present: where we are now
  - Future: what we're going to accomplish and when

Competition Background

- The 19th Annual International Robosub Competition
  - Advance development of Autonomous Vehicles
  - Perform realistic task
- Competition Challenges
  - Interact with color buoys
  - Navigate through a gate
  - Drop markers
  - Fire torpedoes through target
  - Grab and move an object
  - Travel toward pinger
  - Specific competition rules released in December

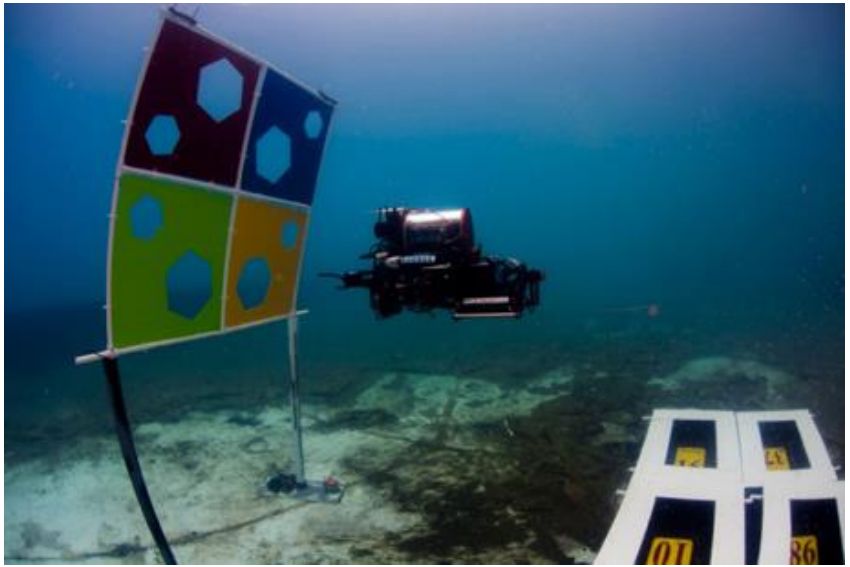


Figure 1: Obstacles at 2015 Robosub Competition

Major Competition Constraints

	Scoring
AUV Weight > 125 lbs	Disqualified
125 lbs ≥ AUV Weight > 84	Loss of 250 + 5(lb – 125)
84 lbs ≥ AUV Weight > 48.5	Bonus of 2(84 – lb)
AUV Weight ≤ 48.5 lbs	Bonus of 80 + (48.5 – lb)

Table 1: Competition weight constraints

- Geometry Constraints
  - AUV must be no larger than 6’ x 3’ x 3’
- Buoyancy
  - Buoyant to 0.5% when kill switch activated
- Weight Constraints
  - Less than 125 lbs

Project Background

- The Current AUV
  - Designed and Built in 2013
  - Weighs about 80 lbs without electronics
  - Contains 22.5 lbs in weights within the hull
- Components
  - 6 Seabotix thrusters
  - Zotac Mini Computer
  - Arduino Mega
  - 2 Arduino Uno's
  - 3 Canakit Motor Controllers
  - 9 DOF IMU
  - 2 Cameras

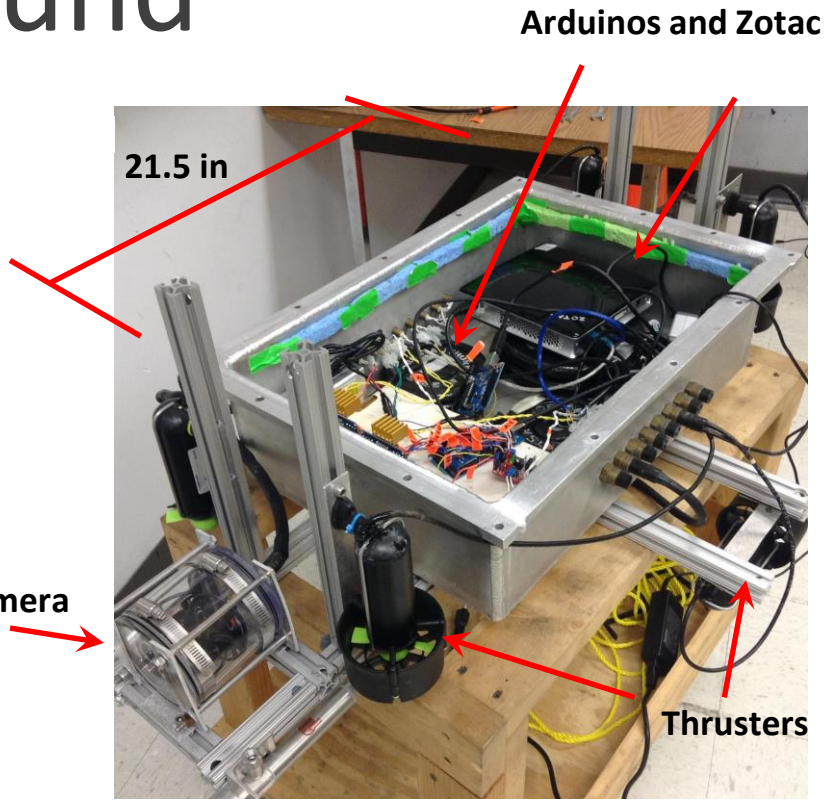


Figure 2: 2015 Robosub

Current Team Organization

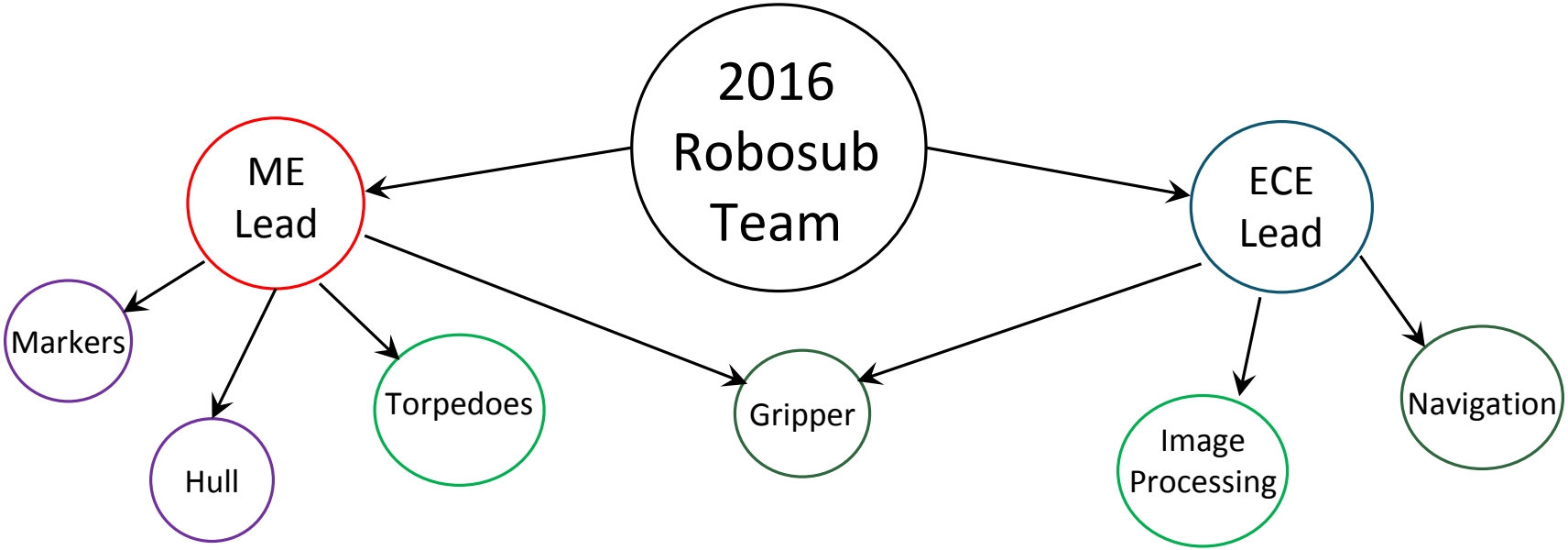


Figure 3: Team Structure

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

Testing

- Buoyancy and waterproof pool testing
  - Vehicle over buoyant by 15 lb
- Dry testing of thrusters and motor controllers
  - All thrusters and motor controllers working properly
- Preliminary testing of navigation software using object visualization to control thrusters

Figure 4: Pool testing at morcom aquatics center

Team Accomplishments

- Camera update
  - Object Detection Working
  - IMU outputs data
- Thruster update
  - Joint effort between teams to work thrusters
  - Replaced motor controller- All six thrusters now operational
  - Thrusters adjust speed to direct sub towards target

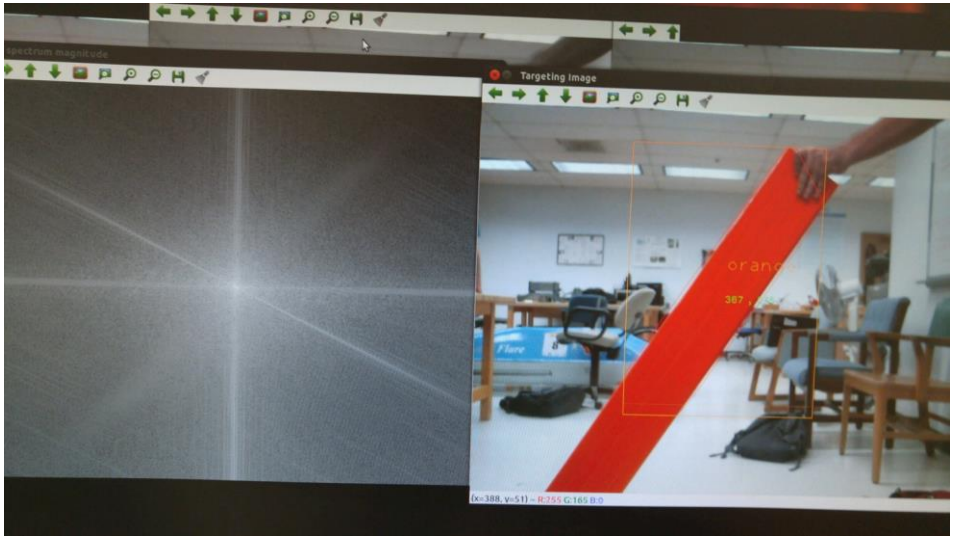


Figure 5: Orientation and Color Identification

Hull Modification

- Modifying the previous year's design by reducing the height by 1.75 in
  - Reduced buoyancy force and weight
- Maintain aluminum hull
  - Heat dissipation decreases with volume

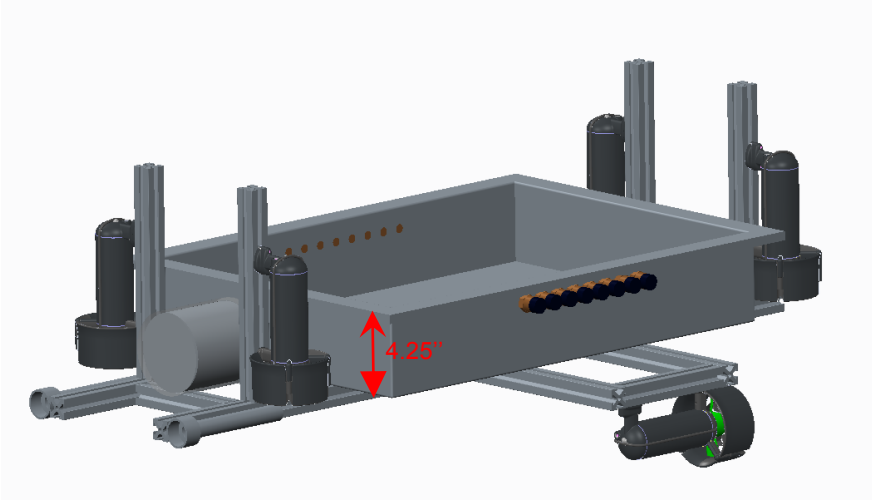


Fig 6: CAD of hull design

Zotac Implementation

- Main CPU
  - Recently established communication to arduino
- Unsuccessful with makeshift battery
- Zotac Battery Output Power
  - Powers Arduino Uno and Mega at 5V each
  - Powers IMU
  - Battery Specifications:
    - Capacity: 4000mAh
    - Input: DC16.8V/1.5A
    - Output: 16V and 19V DC switch

Figure 7: Zotac intel core i3 used in sub

Microcontroller

- Programmed new Arduino Uno to control air actuation for torpedoes and gripper
- Camera sends hi/lo signal to arduino, activating the air actuation valves, releasing pressure
- Test code completed for subsystems
- Awaiting air tank

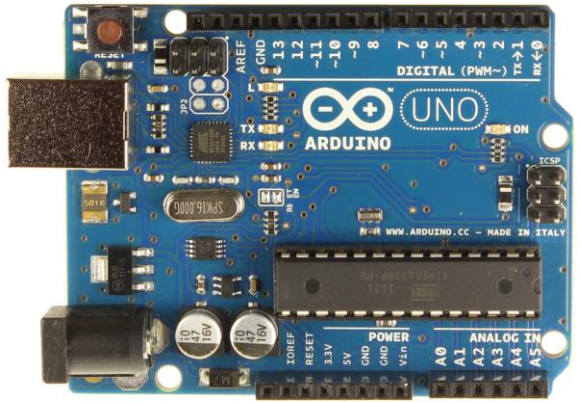


Figure 8: Arduino Uno

Torpedoes

- Design Goals
  - Must fit into current tubing
  - Buoyancy must be only slightly positive
  - Low friction between tubing and torpedo
  - Low drag in the water
  - Stable flight in the water

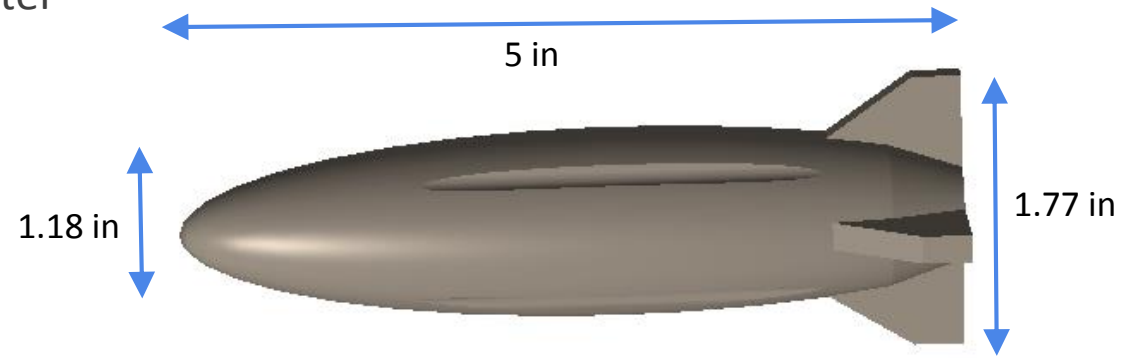


Figure 9: CAD of designed torpedo

Torpedoes

- Air Supply
  - Compressed air tank (3000 psi)
  - Shooting pressure = 100 psi
- New Torpedo
  - Plaster mold of 3D printed torpedo model
  - Rubber torpedo to replace ABS
  - Hollow to add weight

Figure 10: 3-D printed torpedo

Gripper Mechanism

- Pneumatic Actuator: Airtac HFY 16
  - Body size: 30.6mm x 44.6mm x 15mm
  - Gripping angle: $10° \leq \theta \leq 30°$
  - Multiple installation locations

Figure 11: Airtac pneumatic actuator

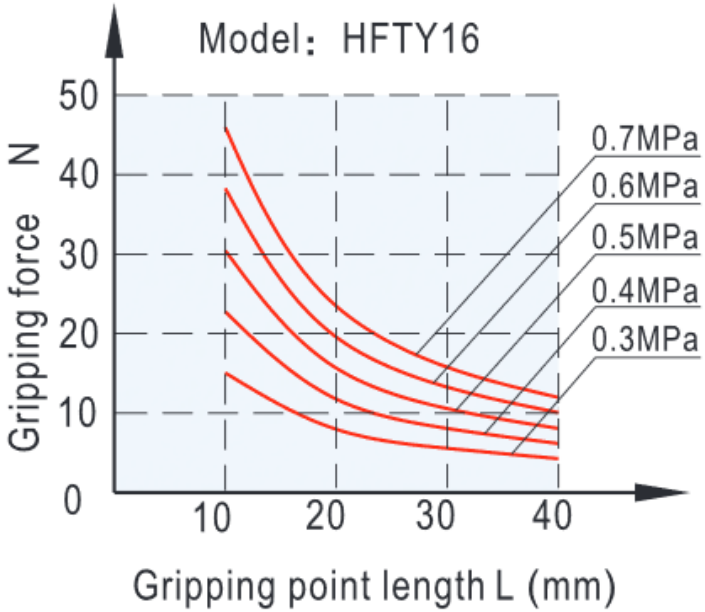
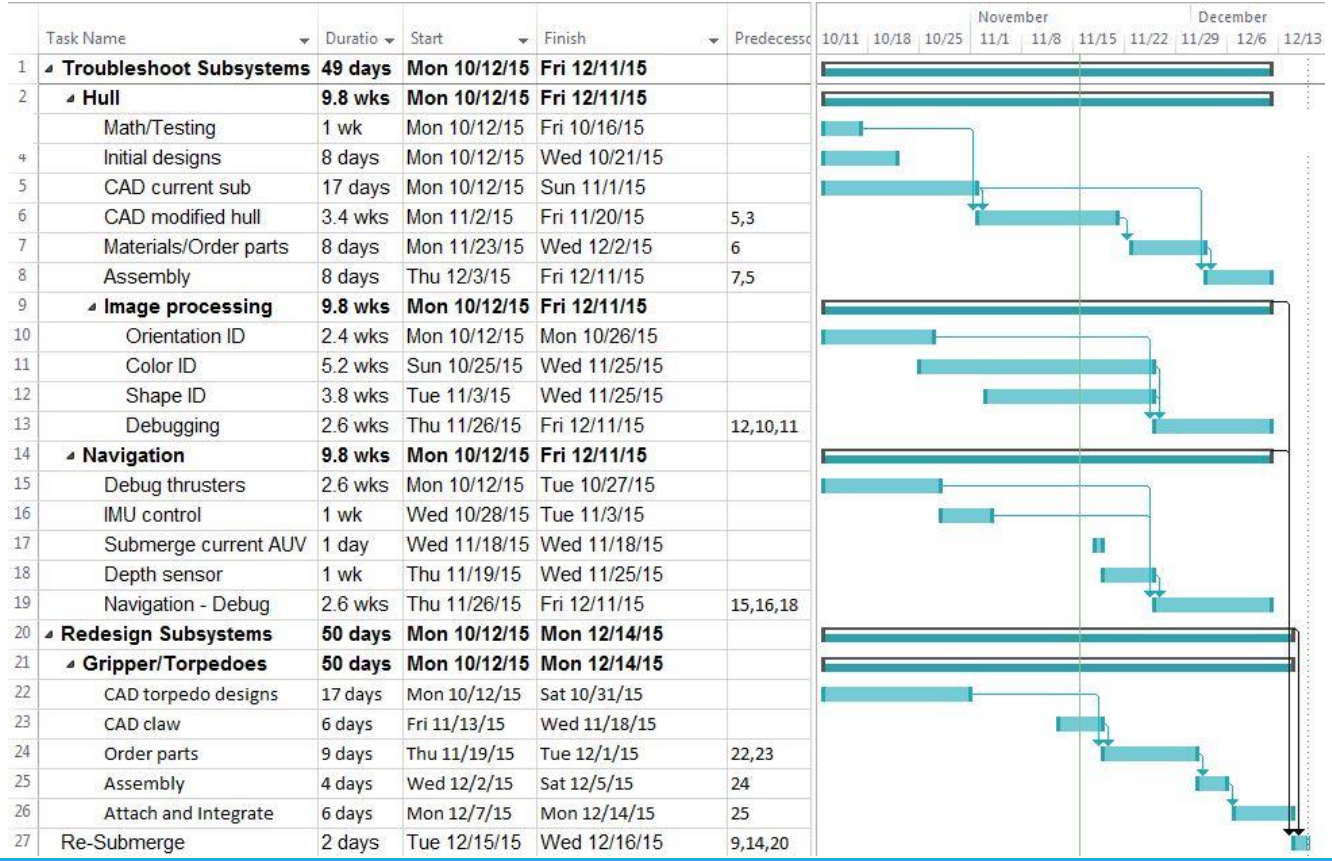


Figure 12: Mechanical Specifications

Future Objectives

- Implement wireless communication to zotac
  - Currently using ethernet through waterproof port
- Complete Mechanical Design
  - Hull cutting and lid fitting
  - Cast rubber torpedo in plaster mold
  - Gripper
    - Attach pneumatic actuators
    - Build gripping hands
- Competition Navigation
  - Develop functions for each movement and task
  - Combine functions into appropriate algorithm

Gantt Chart



	Task Name	Duratio	Start	Finish	Predecessc
1	**Troubleshoot Subsystems**	**49 days**	**Mon 10/12/15**	**Fri 12/11/15**	
2	**Hull**	**9.8 wks**	**Mon 10/12/15**	**Fri 12/11/15**	
	Math/Testing	1 wk	Mon 10/12/15	Fri 10/16/15	
4	Initial designs	8 days	Mon 10/12/15	Wed 10/21/15	
5	CAD current sub	17 days	Mon 10/12/15	Sun 11/1/15	
6	CAD modified hull	3.4 wks	Mon 11/2/15	Fri 11/20/15	5,3
7	Materials/Order parts	8 days	Mon 11/23/15	Wed 12/2/15	6
8	Assembly	8 days	Thu 12/3/15	Fri 12/11/15	7,5
9	**Image processing**	**9.8 wks**	**Mon 10/12/15**	**Fri 12/11/15**	
10	Orientation ID	2.4 wks	Mon 10/12/15	Mon 10/26/15	
11	Color ID	5.2 wks	Sun 10/25/15	Wed 11/25/15	
12	Shape ID	3.8 wks	Tue 11/3/15	Wed 11/25/15	
13	Debugging	2.6 wks	Thu 11/26/15	Fri 12/11/15	12,10,11
14	**Navigation**	**9.8 wks**	**Mon 10/12/15**	**Fri 12/11/15**	
15	Debug thrusters	2.6 wks	Mon 10/12/15	Tue 10/27/15	
16	IMU control	1 wk	Wed 10/28/15	Tue 11/3/15	
17	Submerge current AUV	1 day	Wed 11/18/15	Wed 11/18/15	
18	Depth sensor	1 wk	Thu 11/19/15	Wed 11/25/15	
19	Navigation - Debug	2.6 wks	Thu 11/26/15	Fri 12/11/15	15,16,18
20	**Redesign Subsystems**	**50 days**	**Mon 10/12/15**	**Mon 12/14/15**	
21	**Gripper/Torpedoes**	**50 days**	**Mon 10/12/15**	**Mon 12/14/15**	
22	CAD torpedo designs	17 days	Mon 10/12/15	Sat 10/31/15	
23	CAD claw	6 days	Fri 11/13/15	Wed 11/18/15	
24	Order parts	9 days	Thu 11/19/15	Tue 12/1/15	22,23
25	Assembly	4 days	Wed 12/2/15	Sat 12/5/15	24
26	Attach and Integrate	6 days	Mon 12/7/15	Mon 12/14/15	25
27	Re-Submerge	2 days	Tue 12/15/15	Wed 12/16/15	9,14,20

Figure 13: Allocation of time on project objectives for fall 2015

Risks and Challenges

Risks

- Water damage when testing
- Frying electronics, overheating
- Safety (electricity, weight)

Challenges

- Time management
- Input and output compatibility in code
- Integration of subsystems
- Organization and efficiency of a 10 member team

Conclusion

- Completed:
  - Color and orientation identification
  - Thrusters tested and functional out of water
  - CAD of modified hull
  - Torpedo design 3D printed
- Upcoming:
  - Repair Zotac mini computer
  - Order parts:
    - Zotac battery, aluminum, compressed air tank
  - Pool test to observe mobility
  - Fabrication of modified hull
  - Air actuation implementation and testing

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.

Questions?