PROJECT PROPOSAL & STATEMENT OF WORK

TEAM 4 – ROBOSUB

October 24, 2014

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COMPETITION OVERVIEW

- Hosted by The Association for Unmanned Vehicle Systems International (AUVSI)

- Located in San Diego, CA at the TRANSDEC pool

- Last year's competition had 7 tasks that require the sub to have various abilities

Samantha Cherbonneau   2

INTRODUCTION

Key Requirements

- Run autonomously without any attachments
- Change depth, direction, and speed
- Pass through and around PVC structures
- Recognize colors

Key Limitations

- Must use last year's sub
- Sub must weigh under 125 lbs

Samantha Cherbonneau 3
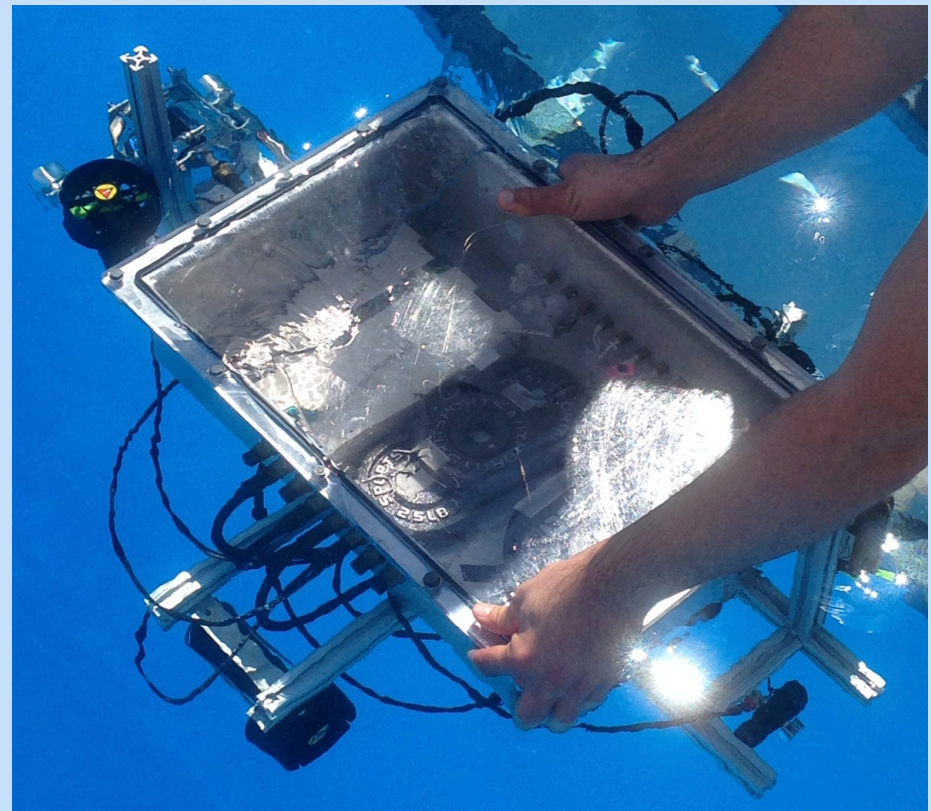
PROJECT MANAGEMENT

- **Dennis Boyd – Programming Lead**
  - Vast programming background

- **Bjorn Campbell – Electrical Lead, Treasurer**
  - Internship at Newport News Shipbuilding

- **Sam Cherbonneau – Secretary, Web Developer, Programmer**
  - Software Engineering Internship with Harris Corporation

- **Kevin Matungwa – Testing Lead, Programmer**
  - Internship with TOPTECH Systems, WFSU-TV Control Tech

- **Elliot Mudrick – Team Lead, Programmer**
  - IEEE Student Chapter Vice President, Math tutor

CONCEPT GENERATION & SELECTION

MECHANICAL & ELECTRICAL DESIGN

- Use same connections/wiring as last year
- Cameras interface directly with the main CPU
- Arduino UNO interfaces with the depth sensor
- Arduino MEGA interfaces with the smaller controllers for the thrusters and the IMU (Inertial Measurement Unit)

Samantha Cherbonneau 6
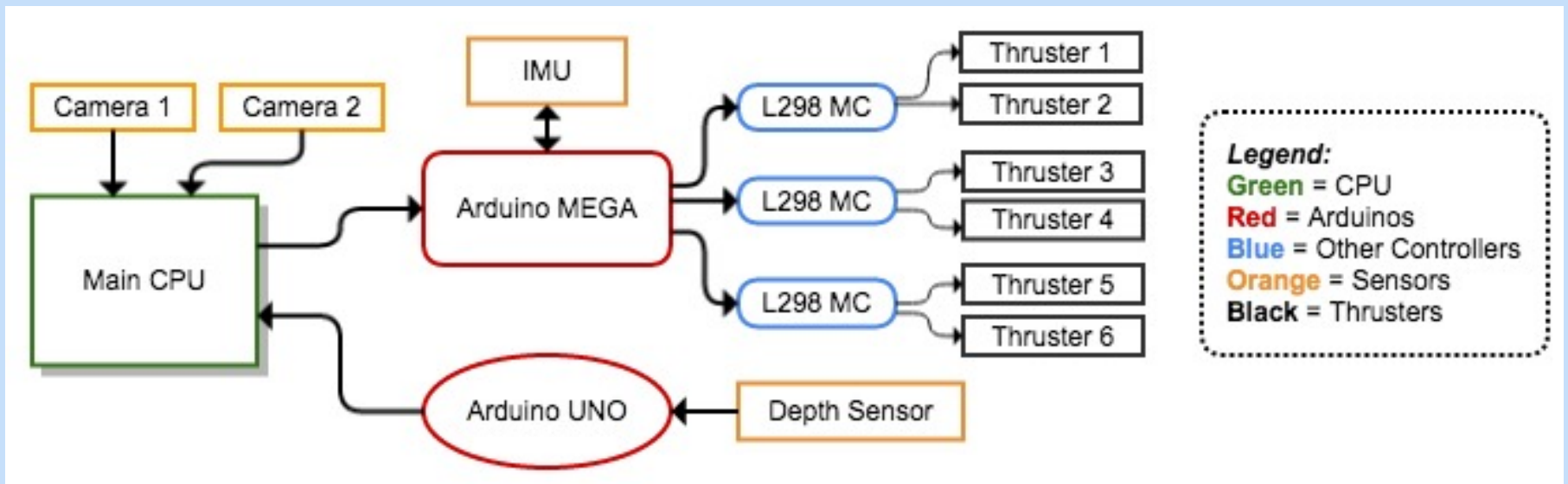
CODE STRUCTURE

- **Build upon last year's code**
  - **It is poorly commented but seemingly functional**
  - **Change sub path implementation**
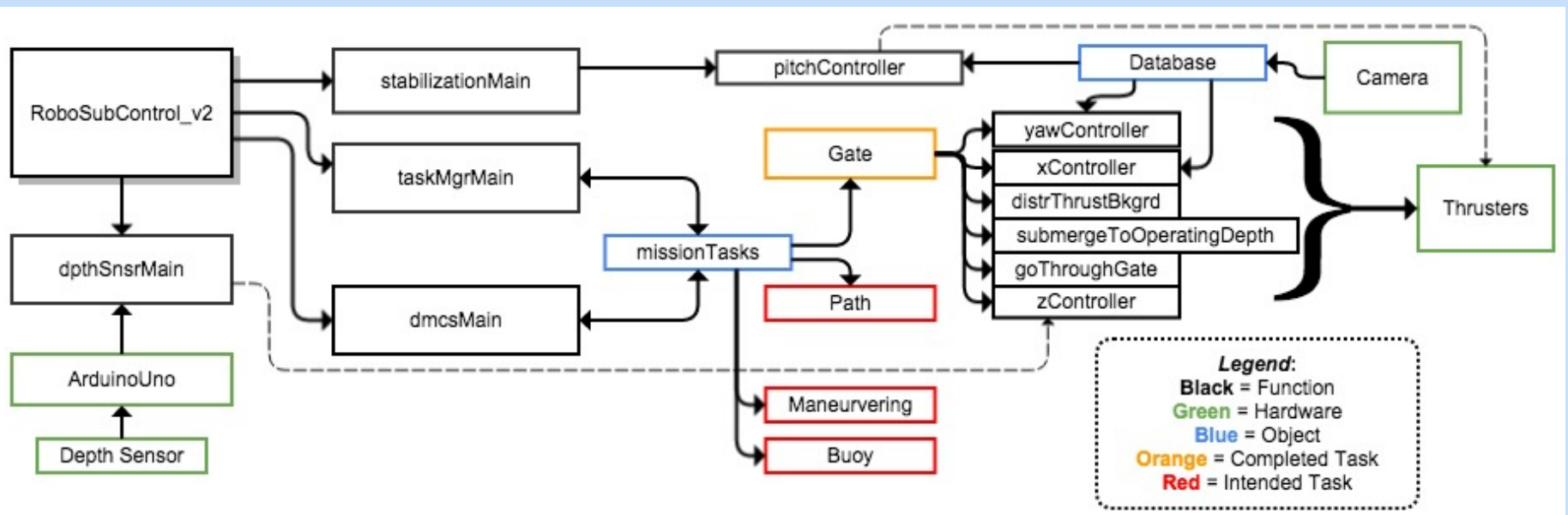
PATH IMPLEMENTATION

- Existing code uses this linear structure:
  - Gate -> Path1 -> Buoy -> Path2 -> etc...

- Make a separate thread for path
  - A single Path thread will be looking to follow a path
  - A flag will indicate when it should begin following

- Will check if it is lost
  - If lost, the flag will be set and the sub will look for a path and get back on track
  - Can adapt if performing a task goes wrong

TASKS & SYSTEM-LEVEL DESIGN

ACCLIMATION

- **Learn the existing code and sub design.**
- **Get sub back to where it was last year:**
  - Going through gate with functional depth sensor.

- **Subtask 1: Reinstall Electronics**
  - Approach:
    - Use last year's User Manual
  - Test/Verification Plan
    - Ensure proper power supplies (using meters).
  - Outcome:
    - Electronics perform properly.

ACCLIMATION

- **Subtask 2: Computer Interface**
  - Understand how to properly connect sub to computer during testing.
  - Approach:
    - Land tests to verify logger is working correctly.
  - Test/Verification Plan:
    - Check logger output within code for specific sections.
    - Compile and run that section and verify that the proper message is displayed.
  - Outcome:
    - Get status updates remotely as sub takes on tasks.
    - This interface will be very useful in the testing and debugging phase.

ACCLIMATION

- **Subtask 3: Checks of Thrusters, Pitch/Yaw, x/y/z Calculations**
  - Verify which thrusters correspond to array in code.
  - Verify pitch, yaw, and x/y/z coordinates received from Razor AHS Inertial Measurement Unit.
  - Approach:
    - Independent land tests to verify components.
  - Test/Verification Plan:
    - Test code to find which thruster is tied to which position in the array by turning them on individually.
    - Play with orientation of Razor AHS and verify its readout.
  - Outcome:
    - Match thrusters to Array 0-5 in code.
    - Confirm valid data coming from IMU.

ACCLIMATION

- **Subtask 4: Gate Movement**
  - Get sub to once again pass through validation gate.
  - Approach:
    - Test sub in water with gate to ensure it can do what it was able to do last year.
  - Test/Verification Plan:
    - Make appropriate pitch, yaw, and thruster adjustments, through a series of tests, until sub consistently makes it through gate.
  - Outcome:
    - Sub successfully, and consistently, moves through validation gate.

COLOR RECOGNITION

- Get sub to recognize color.
  - Orange, red, green, black, and blue.
- Approach:
  - Build upon code from last year.
- Test/Verification Plan
  - Test using multiple objects of various colors.
  - Once this is successful, test with those objects in water.
    - Water may require alteration of color values to give a proper reading.
- Outcome:
  - Sub can recognize colors.

FOLLOW COURSE PATH

- **Recognize Orange path**
  - Use forward camera vision and color recognition function
- **Initial Path Alignment & Maintain Alignment**
  - Adjust yaw thrusters keeping orange tape at the center of the image
- **Navigation Error Checking**
  - Use camera to keep track of position using object tracking
  - If lost begin looking for orange tape
  - Utilize openSLAM (Simultaneous Localization and Mapping) library
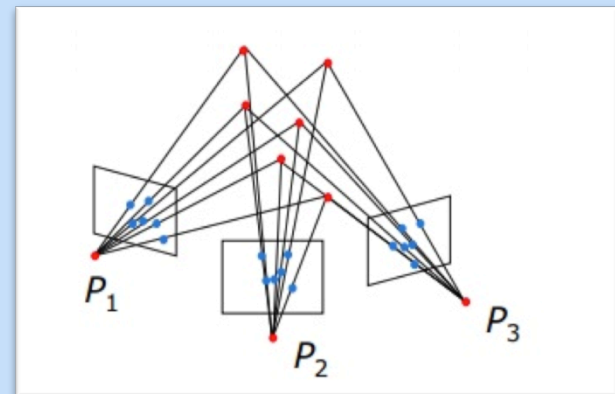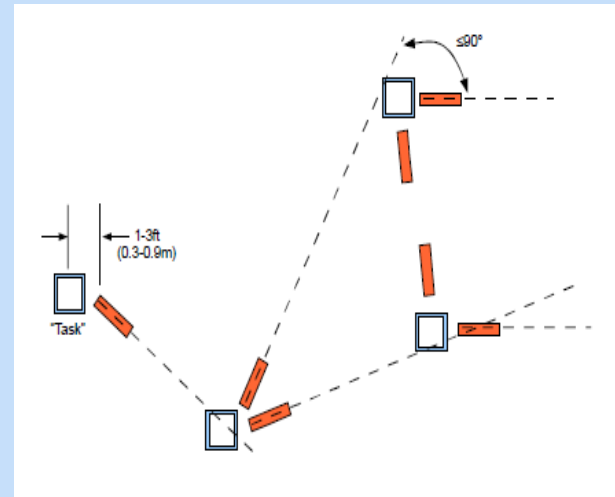
MANEUVERING AROUND OBJECTS

- Identify Vertical red PVC and horizontal PVC pipe using color recognition function
- Orient with pipes
  - Utilize object tracking to find appropriate depth and lateral position relative to pipe alignment
- Circular Movement
  - Maintain sub depth and power the thrusters perform a complete loop maintaining distance from the red pipe

Kevin Matungwa 16
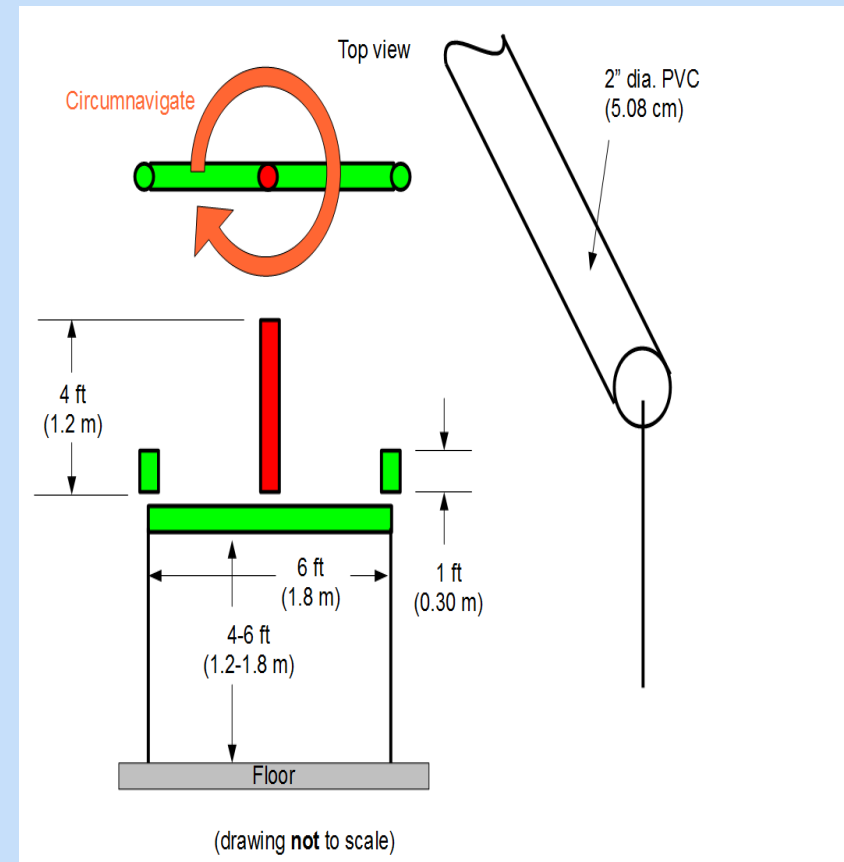
COURSE COMPONENT CONSTRUCTION

- **Rebuild validation gate**
  - Reuse some pipe material from last year
  - Segment gate pipes for easy storage
  - Paint the gate black and tape vertical segment orange blaze

- **Build Maneuvering structure**
  - Easy alteration as this years structure may change

Kevin Matungwa
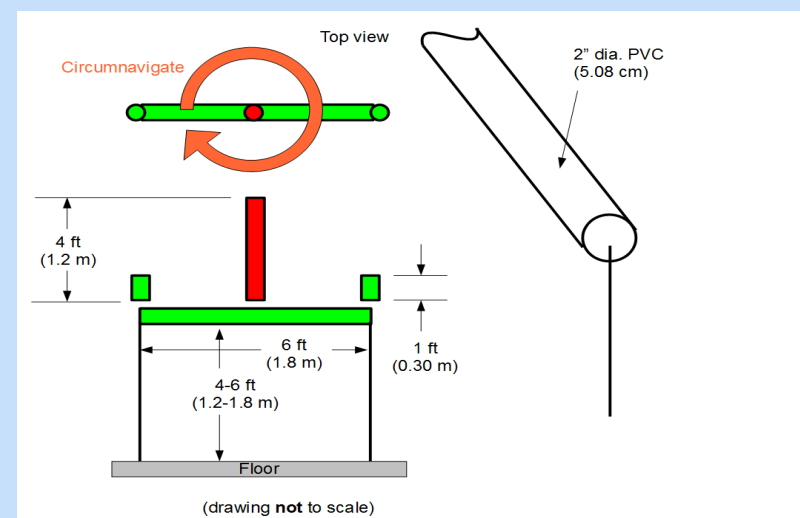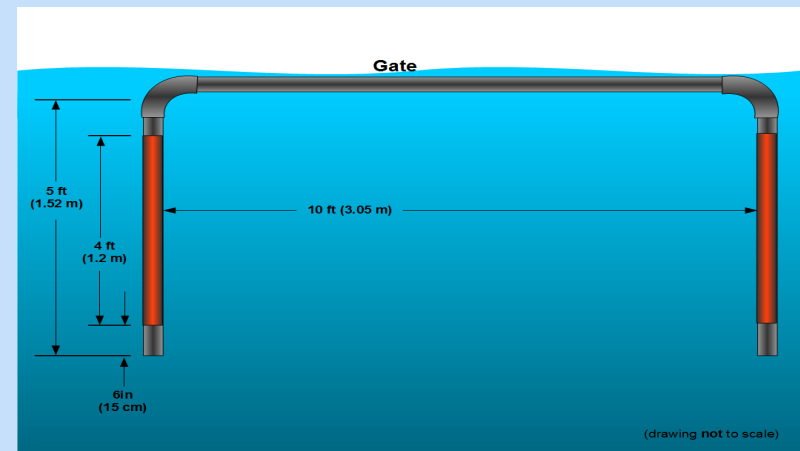
COURSE COMPONENT CONSTRUCTION

- **Orange path**
  - Low cost material that sinks
  - Create 1-2ft raiser
  - Utilize orange tape
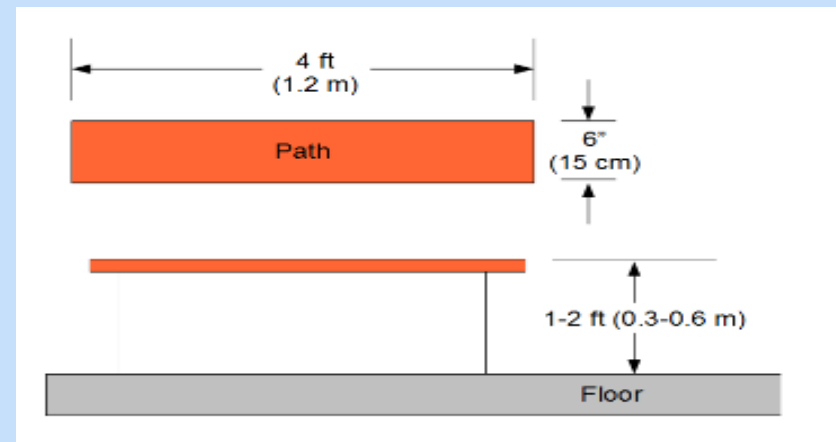
- **LED Buoy**
  - Clear plastic cylinder
  - RGB Remote Controlled Submersible LEDs
    - Three (RGB) LEDs

BUOY CONTACT AND RECOGNITION

- **Subtask 1: Enable the sub to stop in front of buoys**
  - Repurpose the process from the maneuverability task to work with the buoys
  - Conduct preliminary land tests to verify thrusters activate with the buoy at different distances from the camera
  - Repeat tests in the water

- **Subtask 2: Enable sub to recognize color change of buoy**
  - Implement color recognition code for use with the buoy LEDs
  - Conduct land tests to verify that the sub can quickly recognize what color LED the buoy currently has illuminated
  - Repeat tests in the water

Elliot Mudrick

BUOY CONTACT AND RECOGNITION

- **Subtask 3: Bump Objects**
  - **Enable the sub to bump an object and move away again so contact isn't maintained**
  - **Conduct preliminary land tests to verify the forward thrusters activate until contact is made and then verify that the reverse thrusters activate after contact is made. Repeat tests in the water.**

- **Combine all 3 subtasks and ensure they work in conjunction with one another**
- **The sub should continue to bump the buoy until the green LED is illuminated**

Elliot Mudrick

SCHEDULE

	Task Name	Start	Finish	Sep	Oct 5	Oct 12	Oct 19	Oct 26	Nov 2	Nov 9	Nov 16	Nov 23
						Oct					Nov	
1	Repair Gate	10/13/14	11/15/14								Repair Gate	
2	Get Depth Sensor	10/15/14	11/15/14								Get Depth Sensor	
3	Path Construction	11/16/14	12/06/14									
4	⊟ Familiarization	10/13/14	12/05/14									
5	Reinstall Parts	10/13/14	10/18/14			Reinstall Parts						
6	Computer Interface	10/19/14	11/01/14					Computer Interface				
7	Check Thrusters	11/02/14	11/16/14								Check Thrusters	
8	Check Measurements	11/02/14	11/16/14								Check Measurements	
9	⊟ Test Gate Movement	11/17/14	12/05/14									
10	⊟ Measurement adjustments	11/17/14	12/05/14									
11	Yaw	11/17/14	12/05/14									
12	Pitch	11/17/14	12/05/14									
13	X/Y/Z Coordination	11/17/14	12/05/14									
14	Thruster Adjustments	11/17/14	12/05/14									
15	Milestone: Caught up	12/06/14	12/06/14									
16	Maneuverability Construction	01/07/15	02/08/15									
17	⊟ Line Following	01/07/15	02/08/15									
18	Color Recognition	01/07/15	01/24/15									
19	Recognize Orange Path	01/07/15	01/24/15									
20	Path Alignment	01/07/15	01/24/15									
21	Path Traversal	01/07/15	01/24/15									
22	⊟ Water Testing	01/25/15	02/08/15									
23	Debugging	01/25/15	02/08/15									
24	Milestone: Line Following	02/09/15	02/09/15									
25	Buoy Construction	02/08/15	03/22/15									
26	⊟ Maneuverability Task	02/09/15	03/22/15									
27	Identify Vertical Red PVC	02/09/15	03/01/15									
28	Identify Horizontal Green PVC	02/09/15	03/01/15									
29	Orientation	02/09/15	03/01/15									
30	Circular Movement	02/09/15	03/01/15									
31	⊟ Water Testing	03/02/15	03/22/15									
32	Debugging	03/02/15	03/22/15									
33	Milestone: Maneuverability	03/23/15	03/23/15									
34	⊟ Buoy Task	03/24/15	04/24/15									
35	Move to objects	03/24/15	04/10/15									
36	Identify Changing Object Color	03/24/15	04/10/15									
37	Bumping	03/24/15	04/10/15									
38	⊟ Water Testing	04/11/15	04/24/15									
39	Debugging	04/11/15	04/24/15									
40	Milestone: Buoy Task	04/25/15	04/25/15									
41	FINISHED	05/09/15	05/09/15									

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	Task Name	Start	Finish	Dec					Jan				Feb			
				Nov 30	Dec 7	Dec 14	Dec 21	Dec 28	Jan 4	Jan 11	Jan 18	Jan 25	Feb 1	Feb 8	Feb 15	Feb 22
1	Repair Gate	10/13/14	11/15/14													
2	Get Depth Sensor	10/15/14	11/15/14													
3	Path Construction	11/16/14	12/06/14	Path Construction												
4	Familiarization	10/13/14	12/05/14	Familiarization												
5	Reinstall Parts	10/13/14	10/18/14													
6	Computer Interface	10/19/14	11/01/14													
7	Check Thrusters	11/02/14	11/16/14													
8	Check Measurements	11/02/14	11/16/14													
9	Test Gate Movement	11/17/14	12/05/14	Test Gate Movement												
10	Measurement adjustments	11/17/14	12/05/14	Measurement adjustments												
11	Yaw	11/17/14	12/05/14	Yaw												
12	Pitch	11/17/14	12/05/14	Pitch												
13	X/Y/Z Coordination	11/17/14	12/05/14	X/Y/Z Coordination												
14	Thruster Adjustments	11/17/14	12/05/14	Thruster Adjustments												
15	Milestone: Caught up	12/06/14	12/06/14	Milestone: Caught up												
16	Maneuverability Construction	01/07/15	02/08/15										Maneuverability Construction			
17	Line Following	01/07/15	02/08/15										Line Following			
18	Color Recognition	01/07/15	01/24/15						Color Recognition							
19	Recognize Orange Path	01/07/15	01/24/15						Recognize Orange Path							
20	Path Alignment	01/07/15	01/24/15						Path Alignment							
21	Path Traversal	01/07/15	01/24/15						Path Traversal							
22	Water Testing	01/25/15	02/08/15										Water Testing			
23	Debugging	01/25/15	02/08/15									Debugging				
24	Milestone: Line Following	02/09/15	02/09/15											Milestone: Line Following		
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40	Milestone: Buoy Task	04/25/15	04/25/15													
41	FINISHED	05/09/15	05/09/15													

Elliot Mudrick

	Task Name	Start	Finish	Mar					Apr				May			
				Mar 1	Mar 8	Mar 15	Mar 22	Mar 29	Apr 5	Apr 12	Apr 19	Apr 26	May 3	May 10	May 17	May 24
1	Repair Gate	10/13/14	11/15/14													
2	Get Depth Sensor	10/15/14	11/15/14													
3	Path Construction	11/16/14	12/06/14													
4	⊟ Familiarization	10/13/14	12/05/14													
5	Reinstall Parts	10/13/14	10/18/14													
6	Computer Interface	10/19/14	11/01/14													
7	Check Thrusters	11/02/14	11/16/14													
8	Check Measurements	11/02/14	11/16/14													
9	⊟ Test Gate Movement	11/17/14	12/05/14													
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11	Yaw	11/17/14	12/05/14													
12	Pitch	11/17/14	12/05/14													
13	X/Y/Z Coordination	11/17/14	12/05/14													
14	Thruster Adjustments	11/17/14	12/05/14													
15	Milestone: Caught up	12/06/14	12/06/14													
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24	Milestone: Line Following	02/09/15	02/09/15													
25	Buoy Construction	02/08/15	03/22/15				Buoy Construction									
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27	Identify Vertical Red PVC	02/09/15	03/01/15	Identify Vertical Red PVC												
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29	Orientation	02/09/15	03/01/15	Orientation												
30	Circular Movement	02/09/15	03/01/15	Circular Movement												
31	⊟ Water Testing	03/02/15	03/22/15				Water Testing									
32	Debugging	03/02/15	03/22/15				Debugging									
33	Milestone: Maneuverability	03/23/15	03/23/15					Milestone: Maneuverability								
34	⊟ Buoy Task	03/24/15	04/24/15									Buoy Task				
35	Move to objects	03/24/15	04/10/15							Move to objects						
36	Identify Changing Object Color	03/24/15	04/10/15							Identify Changing Object Color						
37	Bumping	03/24/15	04/10/15							Bumping						
38	⊟ Water Testing	04/11/15	04/24/15									Water Testing				
39	Debugging	04/11/15	04/24/15									Debugging				
40	Milestone: Buoy Task	04/25/15	04/25/15									Milestone: Buoy Task				
41	FINISHED	05/09/15	05/09/15											FINISHED		

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ESTIMATED BUDGET

PERSONNEL COSTS

A. Personnel	Total Hours	Hourly Wage	Total Pay
Elliot Mudrick	360	$30.00	$10,800.00
Dennis Boyd	360	$30.00	$10,800.00
Smantha Cherbonneau	360	$30.00	$10,800.00
Kevin Matungwa	360	$30.00	$10,800.00
Bjorn Campbell	360	$30.00	$10,800.00
		Wage Subtotal	$54,000.00
B. Fringe Benefits			$15,660.00
C. Total Personnel Cost			$69,660.00

PARTS

D. Expense	Purpose	Vender	Qty	Price	Total
3" Diameter x 10' Long PVC	Center Horizontal PVC Pipe, Vertical PVC Pipes for Gate	Home Depot	2	$14.68	$29.36
90 Degree Elbows 3" PVC	Connectors for the Gate	Home Depot	2	$2.38	$4.76
R/O Specialty Camo Black Sray Paint	Color white PVC black	Home Depot	1	$3.76	$3.76
Blaze Orange Duck Tape	Vertical color of vertical PVC pipes	Home Depot	1	$3.37	$3.37
1"x6" – 8 FT Weather Shield Wood	Path Lines	Home Depot	2	$5.37	$10.74
Blaze Orange Duck Tape	Vertical color of vertical PVC pipes	Home Depot	1	$3.37	$3.37
Hallow Braid Poly Rope (1/4" x50')	Needed for mooring lines	Home Depot	1	$5.60	$5.60
2" Diameter by 6' Long PVC	Maneuvering parts, Horizontal and Vertical	Home Depot	2	$8.22	$16.44
90 Degree Elbows 2" PVC	Connectors for the Maneuvering Platform	Home Depot	2	$0.83	$1.66
2" Clean Out Tee PVC	Connect center PVC of Maneuvering Platform	Home Depot	1	$3.26	$3.26
Carriage Bolt (¼" X 3-1/2")	Possible to need if Gate test fails	Home Depot	4	$0.78	$3.12
1/4" Nut	Possible to need if Gate test fails	Home Depot	4	$0.14	$0.56
PVC Glue	Need to seal maneuvering structure to become buoyant	Home Depot	1	$4.87	$4.87
2" PVC Caps	Seal vertical	Home	2	$1.64	$3.28
Acrylic 6" Cylinder	RGB Buoy	Lighiting Louvers, Lenses, & Globes	2	$4.95	$9.90
LED Remote	Control the LEDs	100candles.com	1	$4.99	$4.99
Submersible LEDs Red, Green Blue	LEDs for RGB Buoy	100candles.com	5	$3.19	$15.95
16/19 V Ah LI-Ion Universal External Battery	Old Battery output damaged, battery life is limited, two batteries increases testing durations.	AA Portable Power Corp	1	$62.48	$62.48
Depth Sensor	Required for sub, max budget $300		1		$300.00

TRAVEL & OVERALL COSTS

D. Expense	Purpose	Vender	Qty	Price	Total
Plane tickets	Necessary to compete	TBD	3	$250.00	$750.00
Sub Transportation	Necessary to compete	TBD	1	$150.00	$150.00
Car Rental	Necessary to compete	TBD	6	$75.00	$450.00
Expenses Subtotal (excluding tax)					$1,837.47
Expenses Subtotal (including tax)					$1,975.28
E. Total Direct Costs (C+D)					$71,635.30
F. Overhead Costs (45% of E)					$32,235.90
G. Total OCO (E+F)					$103,871.20

RISK ASSESSMENT

PHYSICAL RISKS

- **Transportation**
  - Vibration
  - Accident
- **Waterproof Seal**
  - Old Seal
- **Plexiglass Lid**
  - Pressure
  - Interior Cracks

- **Error in Motion**
  - Crash into pool walls
- **Lighting for Sub**
  - Provide light source if needed
- **Burnout of Components**
  - Heat up
  - Burn out
- **Universal Battery**
  - Damaged Connection

TIMELINE & REQUIREMENT RISKS

- Delays
  - Relying on University Pool
  - Pool hours or events
  - Weather can always interfere with testing
- Component Lead Times
  - Depth Sensor delays
- Official Rules and Requirements
  - Rules and Requirements are posted in Spring Semester

QUESTIONS

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