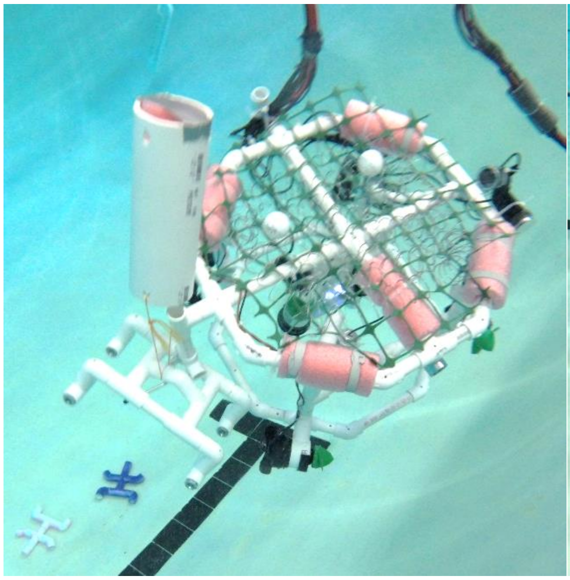
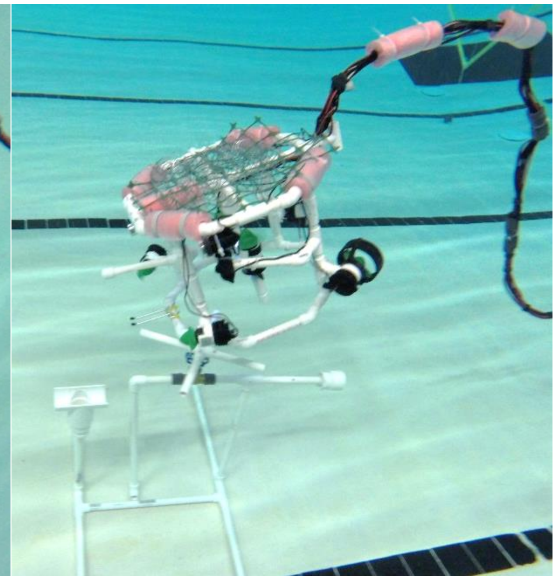
EXPLORER'S INC.

May 2015

Systems & Design Philosophy of Explorer Mark I

Prepared For: Marine Advanced Technology Education, Mid-Atlantic

Advisors: Scott Jarrett, Chris Rao, Jamie Repesh, Angela Jarrett, Chris Repesh

Team Members:

Daniel Becker: Guidance Specialist
Ben Clark: Manipulation Specialist
Josh Clark: Chassis Engineer
Harry Davidson: Pilot, Programmer
Kyle Jarrett: Chief Safety Inspector
Lauren Jarrett: PMO, Director of Buoyancy
Matthew Rao: Executive Propulsion Expert
Ethan Repesh: Manipulation Specialist
Luke Sheakley: PMO

EXPLORER POST 1882
ENGINEERING TOMORROW

MATE

Explorer's Inc.

SYSTEMS & DESIGN PHILOSOPHY OF EXPLORER MARK I

ABSTRACT

Explorer Mark I is an affordable and practical multi-purpose remotely operated vehicle built using standard off-the shelf commercial components. The use of well-known and widely available components and technologies makes the Explorer Mark I a flexible and easy to use underwater platform suitable for any of a variety of missions.

Explorer Mark I was designed and built by Explorers Inc, a wholly owned subsidiary of Engineering & Technology Post 1882 headquartered Haymarket Virginia. Explorer Post 1882 is a co-ed STEM focused engineering club for young men and women dedicated to exploring a variety of fields in Engineering and Computer Sciences in order to help young adults make educated decisions on future career possibilities. We also engage in competitive robotic challenges, take field trips to area employers and facilities, and provide STEM community outreach programs. Explorers Inc. is 1,160 miles from the 2015 international competition in St. Johns Newfoundland Canada. This is the team's first time competing in the MATE competition.

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EXPLORER MARK I – DESIGN & BUILD PROCESS OVERVIEW

Our goal for this our first MATE competition was to learn more about remotely operated vehicles and underwater robotics. To that end the team started with a review of the various components/subsystem of an ROV and the design requirements dictated by the Artic missions. The team then organized itself into sub-teams focused on the various subsystems including: propulsion, guidance/navigation/control, buoyancy, and chassis as well as the project-level requirements including: project management and safety. Each sub-team was then tasked with designing, building and testing their subsystems or other deliverables. Our overall design process was highly interactive and iterative. Each meeting started with a quick overview of where the ROV build stood and then immediately progressed into series of trial and error loops (design, build, and test).

Company Organization

Project Management Office – Team

Two members of our MATE team volunteered to start and run the Project Management Office (PMO). We met to first understand the goal and purpose of the PMO and then came up with a plan on how we wanted to manage the MATE project.

Additionally part of our role was to explain to the rest of team what a PMO is and does as well as the key milestone and deliverable dates for the project.

Guidance Navigation and Control Team

Four member of our MATE team were responsible for designing, implementing and testing our guidance/navigation and control subsystems. Their challenge was to determine how the ROV would navigate under the ice and control the propulsion.

Propulsion Team

Being our first year in underwater robotics the propulsion team decided to use the materials we had on hand to design a propulsion system that would move the ROV in the directions needed to perform the missions.

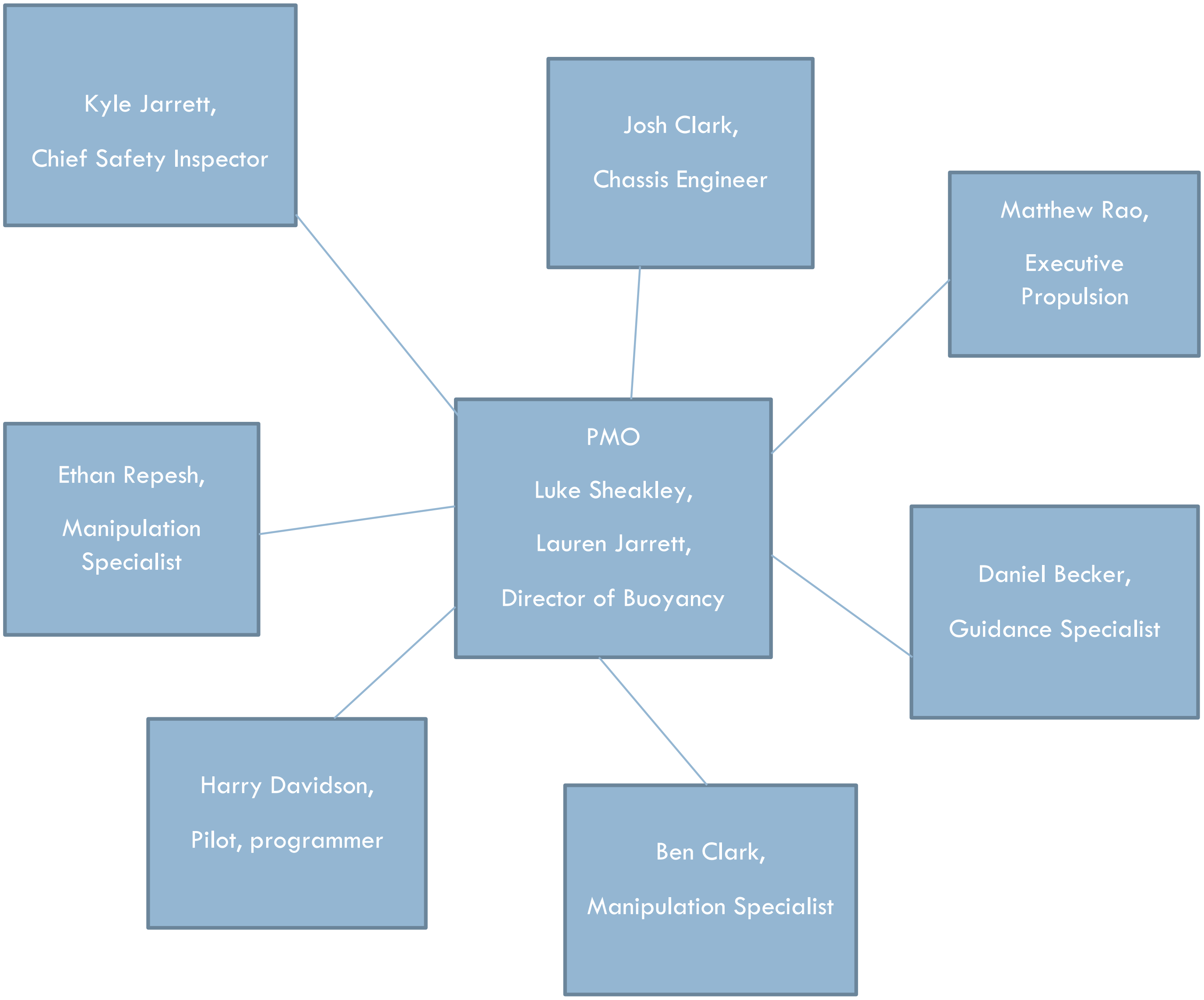
Chassis Team

The chassis team focused on providing a framework/chassis which would support the various design requirements from the other sub-teams. Specifically we were tasked with building a chassis to support the propulsion subsystems, the various cameras and instruments use for navigation and the various safety features required.

Sales & Marketing Team

The sales and marketing team was made up of members from the other sub-teams each of whom provided input on how their sub-team was meeting the design requirements for the project.

Company Role Chart



DESIGN RATIONALE: ROV SUBSYSTEMS

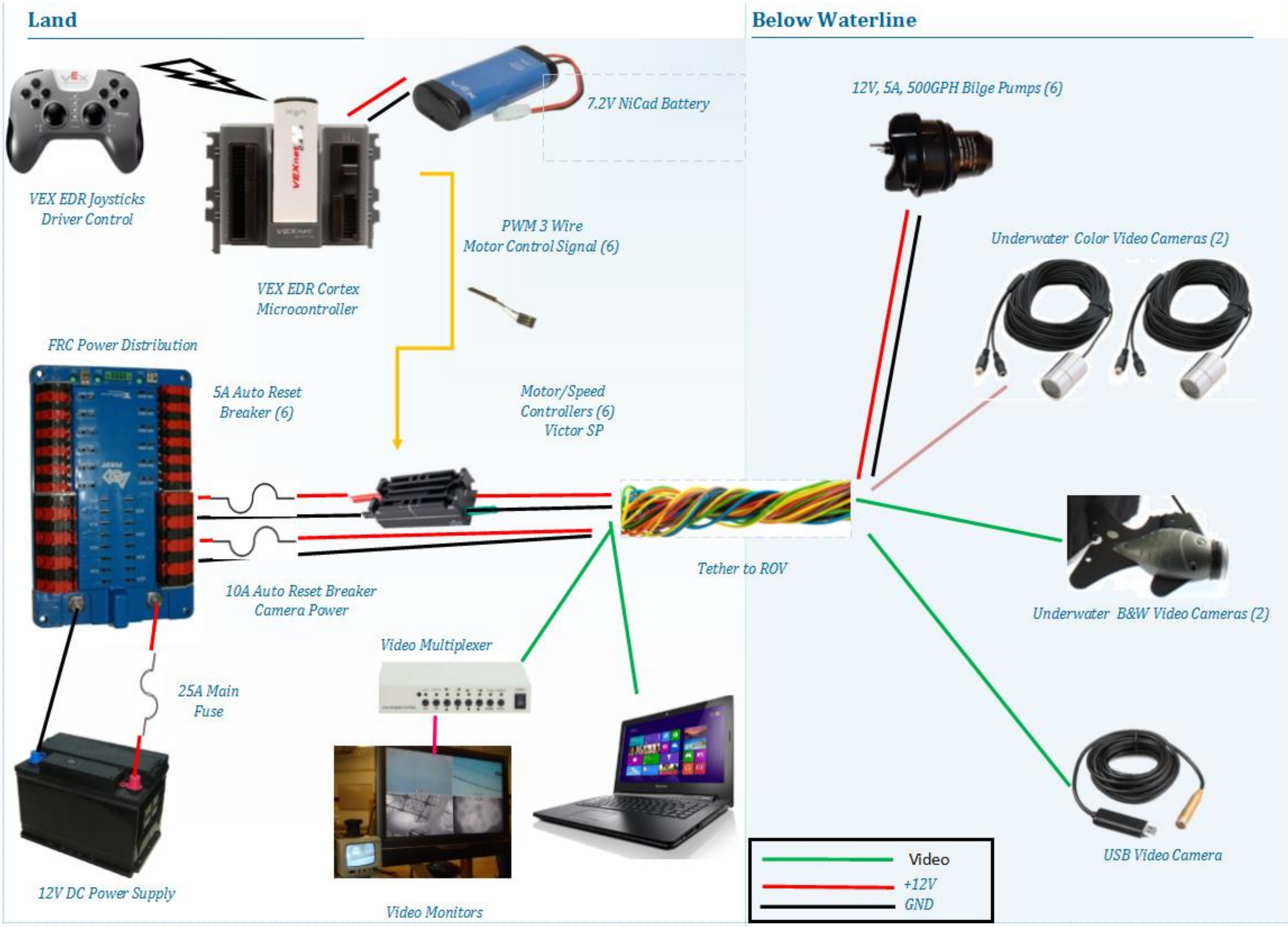
The design of the ROV was accomplished by integrating the various subsystems design by the company's sub-teams. Each team provided input and guidance to the other teams about their needs and how the various components would fit together.

Requirements Matrix

What	How					
Mission Requirements	Structural			GN&C		
Science Under the Ice	Chassis	Buoyancy	Propulsion	Sensors	Control System	Manipulators
Move		X	X	X		
Remove sample algae		X		X	X	X
Return algae to surface		X			X	X
Recognize sea star		X	X	XX		
Remove sea urchin from seafloor		X	X	X	X	X
Return sea urchin to surface		X	X	X	X	
Deploy a passive acoustic sensor	X	X	X	X	X	X
Find/Survey the iceberg		X	X	X	X	
Measure depth of the iceberg			X	XX		
Measure diameter iceberg				X		
Pipeline Inspection						
Conduct a CVI of an oil pipeline to locate the corroded section		X	X	X	X	X
Turn a valve	X				X	X
Examine a gauge dial		X		X	X	
Measure the section of corroded pipeline		X	X	X	X	X
Attach a lift line to the corroded section	X	X	X	X	X	X
Pull two pins	X	X	X	X	X	X
Remove section of corroded pipeline		X	X		X	X
Install flange adapter		X	X	X	X	X
Inserting one bolt on each flange		X	X	X	X	X
Remove wellhead's protective cover	X	X	X	X	X	X
Install gasket into the wellhead		X	X	X	X	X
Replace wellhead's protective cover		X	X	X	X	X
Inserting the hot stab		X	X	X	X	X

System Integration Diagram

The SID below provides a high-level overview of the various ROV electrical subsystems which include: guidance, navigation and control, power, and propulsion.



Chassis

We are using an octagon-shaped chassis, built with half inch thick PVC piping. The ROV measures 39 cm tall x 55 cm wide x 75cm long. The chassis is divided into 3 levels. On the top level is a cross beam to which five pieces of foam noodles are attached for buoyancy. Additionally the attachment for collecting ping pong balls is attached to the center beam. There are 4 vertical beams to which our motors and cameras are attached.

We chose half inch thick PVC piping for our chassis because it is waterproof, easy to work with, and cost effective. It was decided by our GNC team that an X-Drive would be used for propulsion, so we chose an octagon shape with 4 vertical beams to support the X-drive set-up. The additional sides in an octagon allowed for more options on motor, camera and manipulator locations.

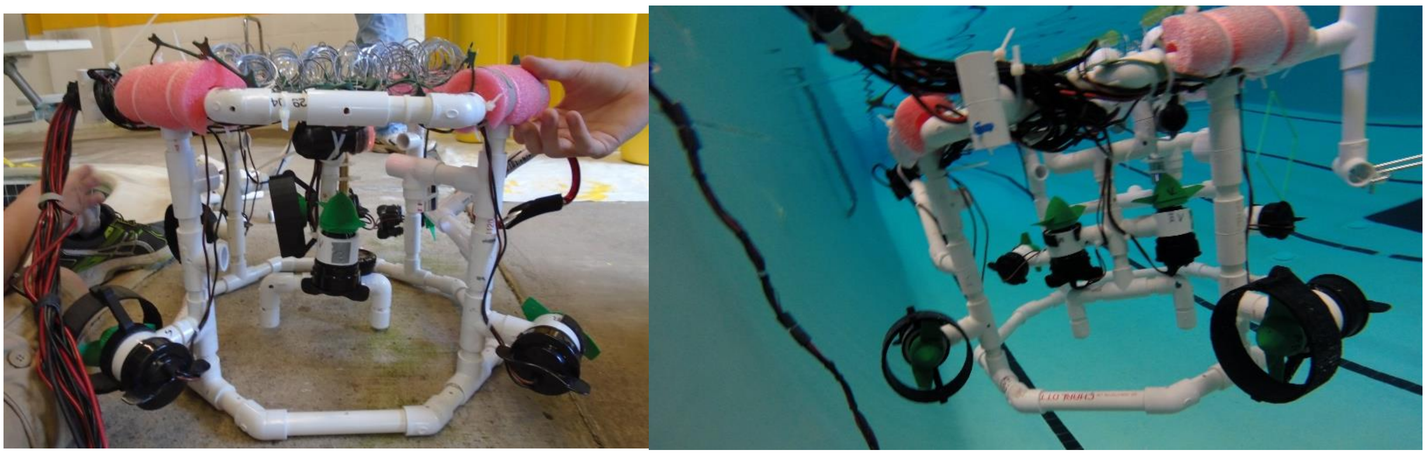


FIGURE 1: CHASIS

Guidance, Navigation & Control

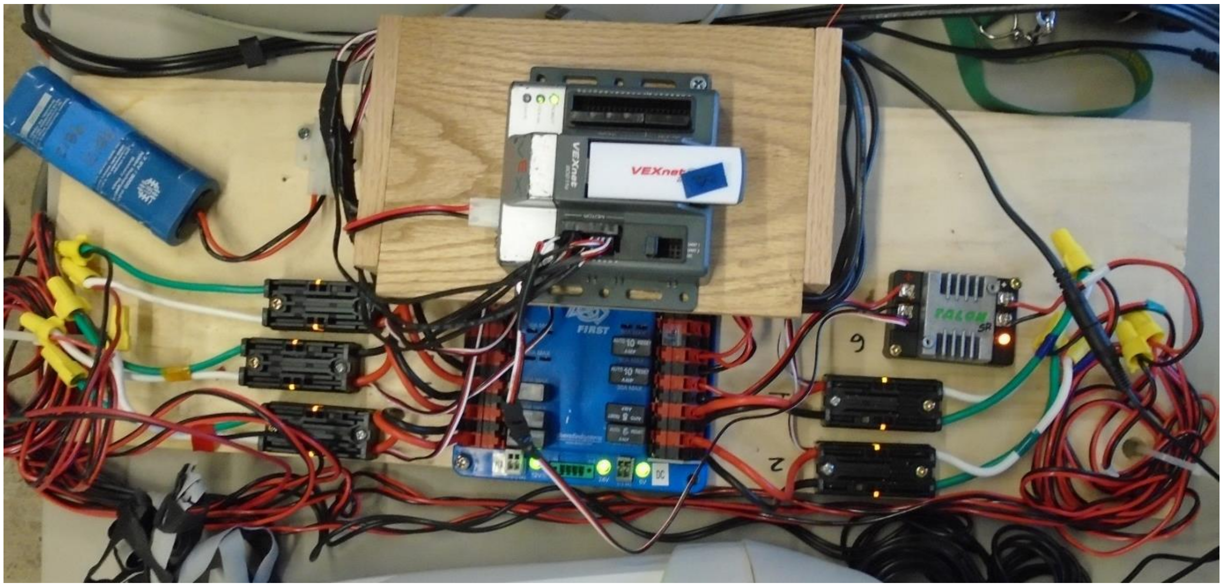


FIGURE 2: CONTROL SYSTEM

We decided to use a VEX CORTEX microcontroller as the brains for our control system as many of the team members have experience with the VEX robotics platform. Also we had several VEX microcontrollers available and ready to use. Many of our team members play video games and vex joysticks are almost identical to game console controllers so it makes it easier for our drivers to maneuver the ROV.

Tied to the microcontroller we purchased Victor SP motor speed controllers. These motor controllers are needed because the VEX Cortex is not designed to drive large motors like the bilge pumps we used for our propulsion system. The VEX cortex sends control signals (PWM) to the speed motor controllers which use those signals to provide current to the bilge motors.

We used a loaned FRC (First Robotics Competition) power distribution board to provide a central source for 12V power to all of the various motors and cameras. The power distribution board is used to safely distribute battery power via auto-reset thermal breakers and WAGO connectors.

In order to organize and isolate the control system all of the control system components were mounted to a wood board which will not conduct electricity. This provides a stable 'table' for the control system as well as provide protection for the various components/parts.

FIGURE 3: VEX CORTEX

FIGURE 4: VEX WIRELESS JOYSTICK

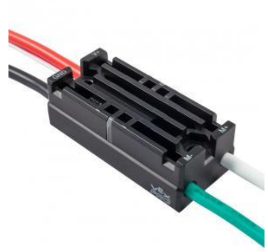


FIGURE 5: MOTOR SPEED CONTROLLER

FIGURE 6: POWER DISTRIBUTION BOARD

Tether

The tether provides power to the six thrusters and four cameras as well as returns video signals from the cameras to the on-land monitors. The power/motor wires are a combination of 12-18 gauge copper stranded wires. We initially tried using Ethernet wire to provide power to the motors but the wire was too thin and caused the motors to draw too much current and constantly throw the thermal breakers. We used standard video wires in the tether for the video camera wires.

The floats are attached to the tether by zip ties, and are put there to keep the tether neutrally buoyant and to keep the wires out of the way. The zip ties and additionally Velcro ties are used to keep the wires in the tether in place. In total, there are 12 wires coiled in the tether.

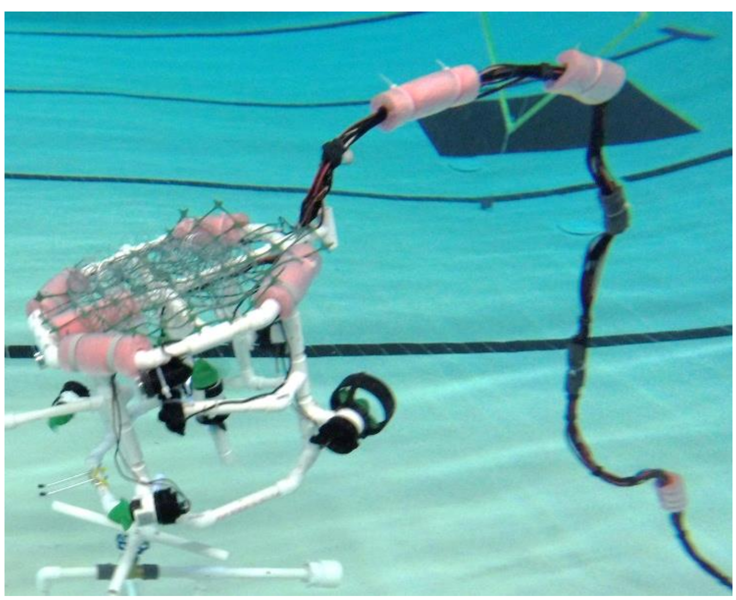


FIGURE 7: ROV TETHER

Guidance

One of the largest challenges faced by the team was guidance and navigation. The requirement that we be able to drive the ROV under the ice meant we would not be able to see the ROV to guide it or control it. This is very different from the teams past robotics experience. Luckily we have five black and white video cameras which were loaned to the company by one of our sponsors. From nearly day one of the build phase of this project we have been testing various camera configurations and locations in a trial and error approach.

Eventually the team decided it would be impossible to compete in the challenge without at least a couple of color cameras. So we ordered two wide angel color cameras – one for front view and the other for a downward view (towards the sea stars). While the color cameras were helpful we were still stuck with a set of 5-6 small video monitors (5 black and white; 1 color). The small screens and the large number of screens made navigating around the practice pool difficult.

After unsuccessfully trying several software solutions to integrate the various videos onto a single monitor and/or laptop the team purchases a hardware based solution, a video multiplexer. The multiplexer, like the ones designed for video surveillance systems, worked great. It is simple to use, reduced our number of required monitor from 5 to 2.

FIGURE 8: GUIDANCE CAMERAS – INTIAL DESIGN

FIGURE 9: GUIDANCE CAMERAS - FINAL DESIGN

CAMERAS

FIGURE 10: COLOR – WIDE ANGLE

FIGURE 11: B&W FISH CAMERA

FIGURE 12: VIDEO MULTIPLEXER

Navigation

Initially the team brainstormed elaborate navigational systems using virtual reality and sonar to navigation around the pool, but give the time crunch and the team's lack of experience with these technologies we decided to navigate around the pool with a simple and low tech solution. So we decided to use the parts we had on hand and ready to go - a lot of cameras and a dive computer (depth, bottom time, etc.) and compass.

One of the B&W monitors is dedicated to providing a live video of the dive compass, which tells the driver which direction the robot is pointing and traveling, and the dive computer, which provides the ROVs depth and amount of time on the mission clock.

FIGURE 13: NAVIGATION INSTRUMENT PANEL

Propulsion

The team initially experimented with the standard yellow propellers which came as part of the pufferrish ROV kit but quickly realized during testing that the propellers provided very little thrust. After some research we realized that those propellers where really designed for remote control motor boats which mostly only need forward thrust.

In talking with folks at a local RC hobby shop we realized we needed a propeller designed just for ROVs something that would provide more thrust at slower speeds and would work equally well in forward or in reverse.

We chose to design a customer propeller. We researched and found a company which sells ROV thrusters and propellers as well as a standard CAD model for 3D printing of their propellers. We started with Bluerobotics M100 thruster and created our own custom 3D CAD model for our propeller – it is larger and uses a different motor mount. The M100 have a flatter pitch (i.e. provide equal thrust in forward or reverse) and can run at slower speeds (i.e. decreased cavitation).

We attached custom designed 3-D printed Bluerobotics M100 thrusters to six 12V/5 Amp bilge pumps for propulsion. The pumps are capable of 500 GPH. The thrusters are protected by 3-D printed shrouds and attached to the chassis using PVC connectors. We are using 5 of the thrusters to control horizontal motion in an X-drive set-up. The sixth thruster is being used to control vertical motion.

FIGURE 14: ORIGINAL M100 DESIGN

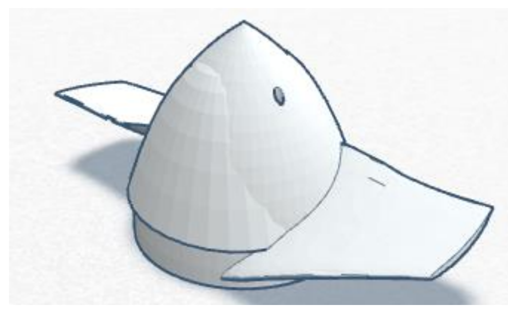


FIGURE 15: TEAM MODIFIED PROPELLER - HORIZONTAL

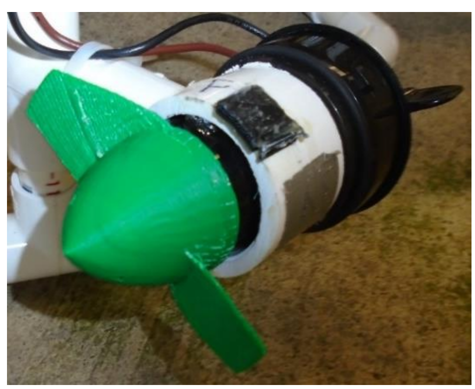


FIGURE 16: CUSTOM 3D PRINTED PROPELLER

In our first trials, we used 4 thrusters to control horizontal motion and 2 to control vertical motion. We found that we were in need of more horizontal speed, and that we had too much vertical speed. One of the vertical thrusters was changed to a horizontal position, providing us with optimum speeds for both horizontal and vertical motion.

Manipulators

In order to accomplish various mission tasks the team designed, built and tested several manipulators. These are attachments, mostly passive, which enable the ROV to perform/complete the various mission tasks.

Measuring tool

FIGURE 17: ROLLING TAPE MEASURE

- Rolls along the pipe to measure it in inches.

Algae Collector

FIGURE 18: ALGAE COLLECTOR

- We used a slinky for this task.
- The green mesh is used to make sure the slinky doesn't collapse on itself or into the chassis of the ROV.
- The slinky pushes the algae (Ping pong balls) up against the ice.
- The algae (ping pong balls) doesn't have a very good chance of escaping.

Sea Urchin Hooks

FIGURE 19: SEA URCHIN HOOKS

- Using metal hooks with rubber on the end
- Goes through o ball and picks it up

Acoustic Sensor mount

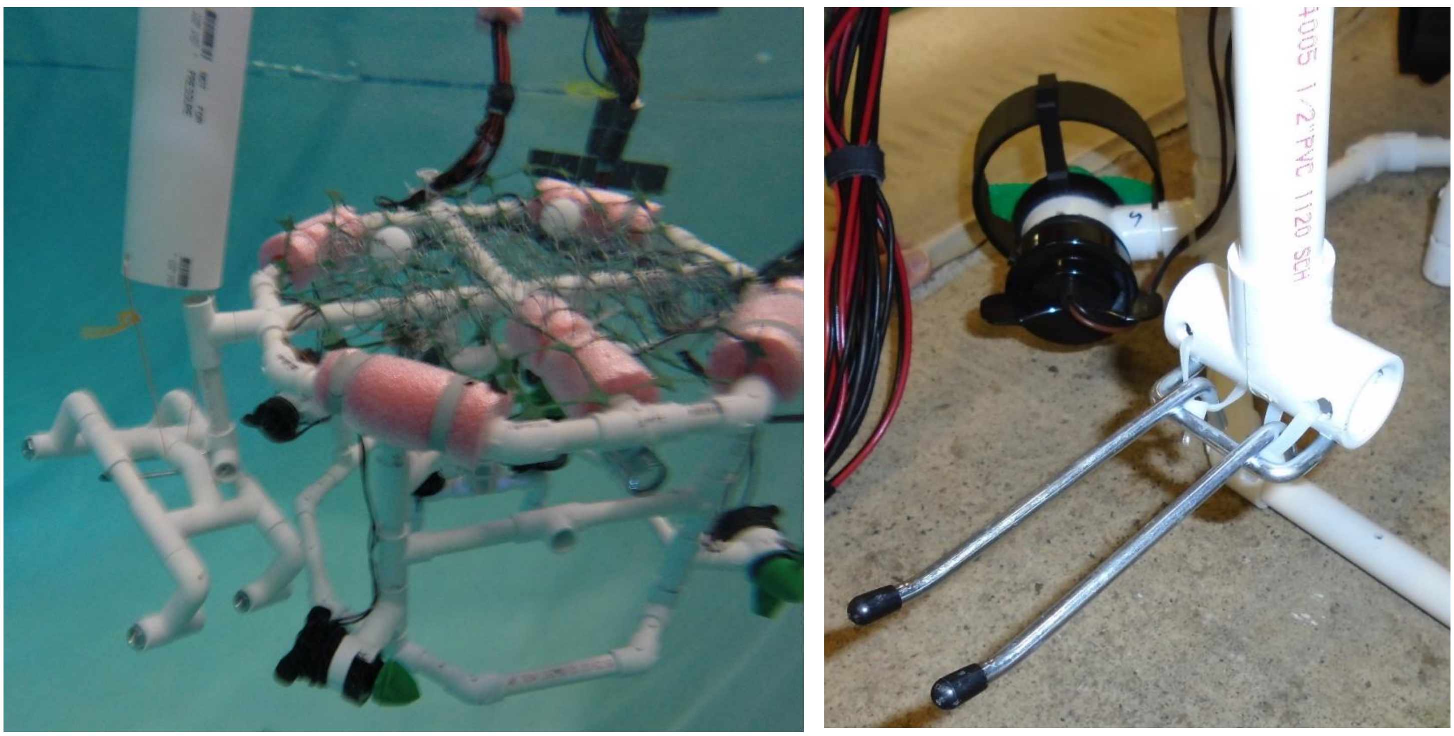


FIGURE 20: ACOUSTIC SENSOR MOUNT

Pipe Retrieval

FIGURE 21: PIPE RETRIEVAL HOOK

- Using a hook with a carabineer attached to it simulates picking up the corroded section of pipe.
- The hook is connected to a PVC pipe while the carabineer is made to lift the pipe with a mini tether built into the PVC pipe.
- The carabineer is attached to the chassis by a piece of Velcro built into the PVC pipe, so that it can break off at any time.

Pipeline/Iceberg Measurement

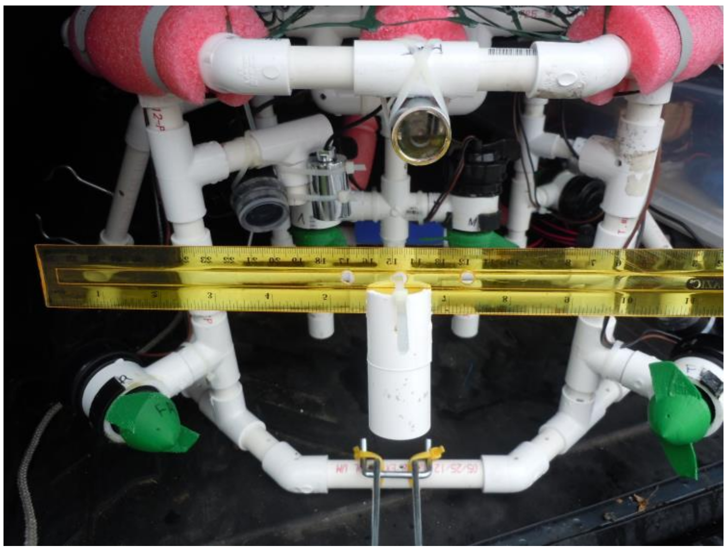
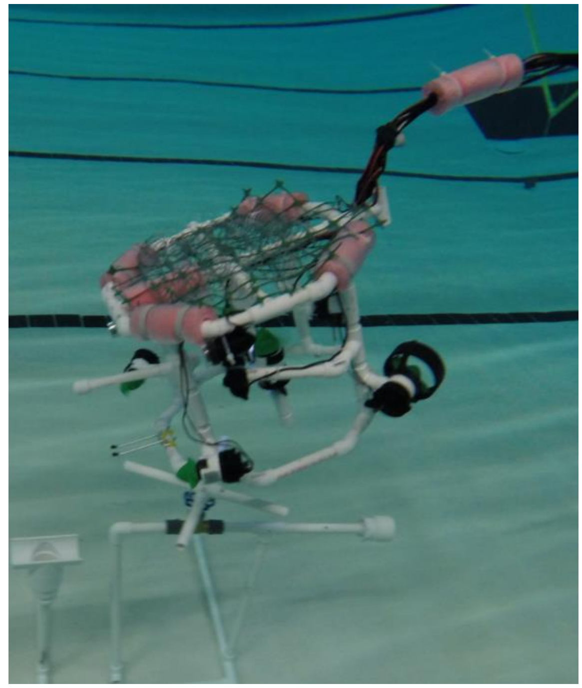


FIGURE 22: RULER PIPELINE/ICEBERG MEASURMENT

Pipeline Valve – Open/Close

We designed a 'fork' to sit on top of the valve. Then we can open/close the pipeline valve by simply rotating the ROV clockwise/counterclockwise. The bottom facing camera provides a birds-eye view of the valve.

FIGURE 23: PIPELINE VALVE OPEN/CLOSE



Buoyancy

The buoyancy team focused on ensuring that the ROV was neutrally or slight negatively buoyant and had a righting moment which would ensure the ROV remained stable and upright in the water during the missions. Originally, we tried using a donut float made of a single circular plastic air sack shaped like a donut. While this provided the ROV with a lot of lift and was easy to adjust (inflate/deflate) the donut had a fatal flaw. When submerged all of the air in the donut would go to the high side of the donut and the ROV would float unevenly. Since the donut was one big chamber there was no way to spread the air evenly.

After some trial and error the team decided to use foam noodles to provide the positive buoyancy for the ROV. By evenly spreading the foam poodle noodles around the ROV to allow it to float level making it easier to maneuver the ROV. Additionally foam floats (pipe insulation) was added to the tether to make it close to neutrally buoyant in order to reduce the drag on the ROV.

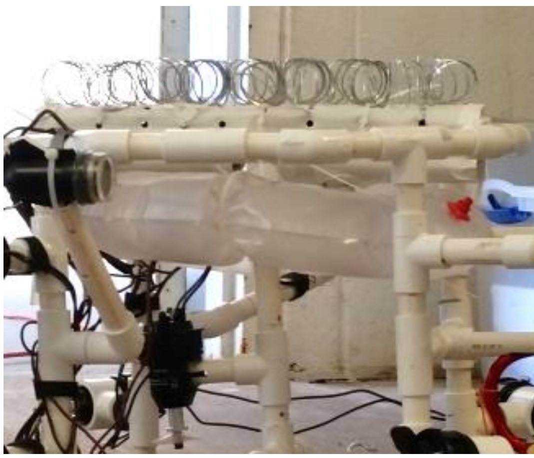


FIGURE 24: ORIGINAL BOUYANCY DONUT

FIGURE 25: CURRENT BOUYANCY FOAM FLOATS

SAFETY

The team designed in several safety features.

- Power Distribution board
- 25A main fuse and individual 5A/10A fuses thruster
- Custom 3D printed thruster shrouds
- Waterproof wiring
- Plastic enclosure for control & power subsystems

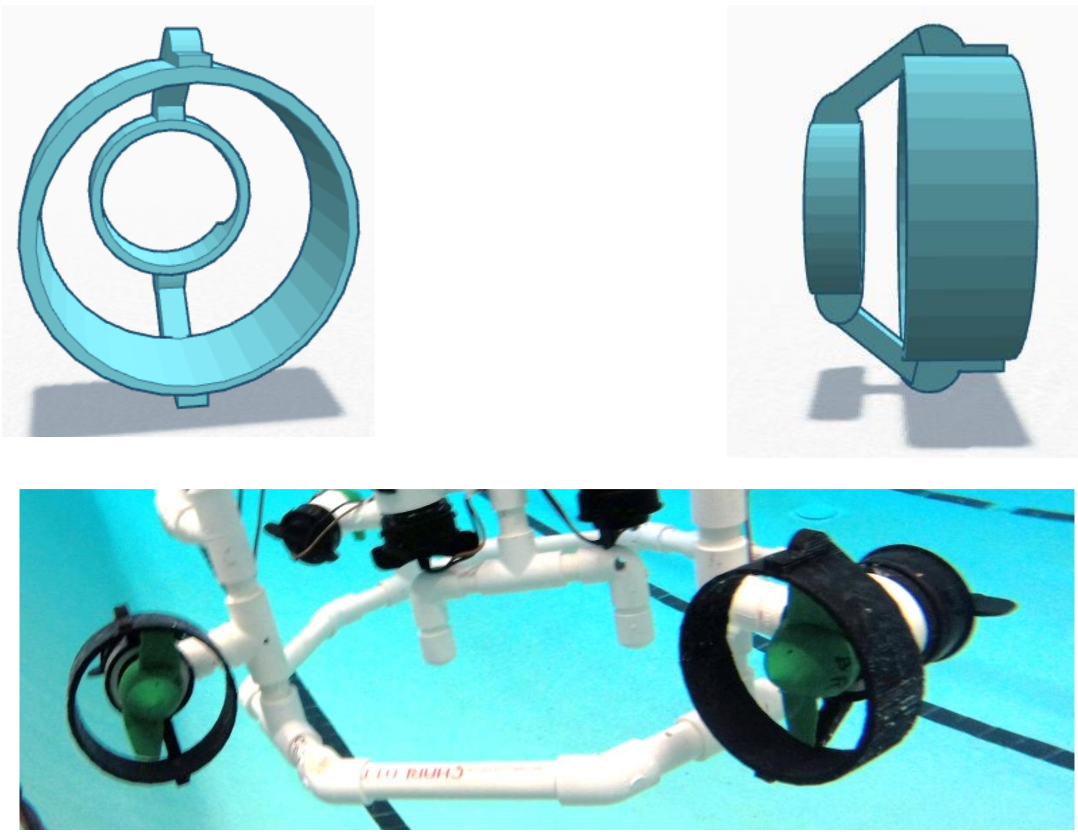


FIGURE 26: CUSTOM THRUSTER SHROUDS

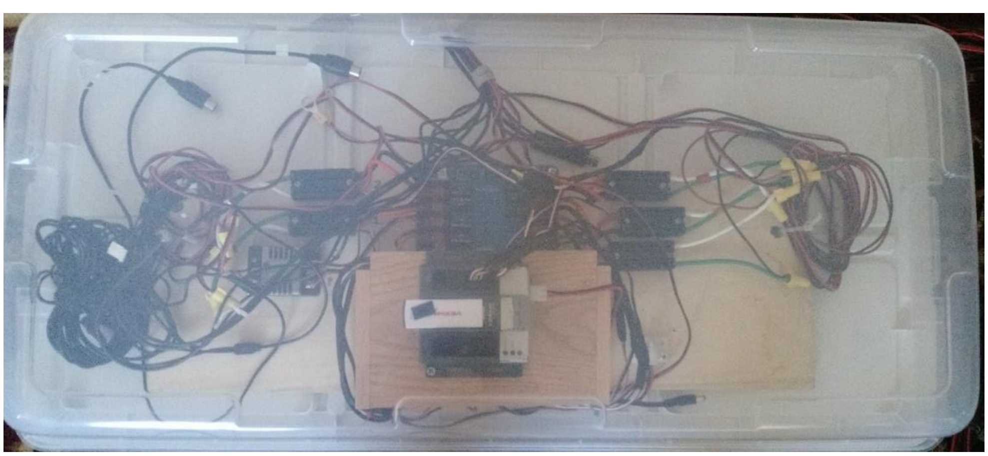


FIGURE 27: SAFETY ENCLOSURE FOR CONTROL SUBSYSTEM

PROJECT SCHEDULE

	03/16/15	03/23/15	03/30/15	04/06/15	04/13/15	04/20/15	04/27/15	05/04/15
Key Milestones				**Pool**	**Osborne Pk 4/16**		**Pool 4/28 & 4/30**	
					Circuit Diag 4//17		Regional 5/2	
Demonstration (300)								
Chassis								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Buoyancy								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Propulsion								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Sensors								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Controls								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Manipulators								
Documentation		Outline	Draft 1		Draft 2			
Design	Draft 1	Draft 2		Final Design		As-Builts		
Construction								
Test								
Engineering & Communications (250)								
Documentation (100)		Merged Outline						
Sales Presentation (100)								
Marketing Materials (50)								
Safety (30)								

BUDGET

	Qty	Source	Cost	Value
Registration	1	MATE	$ 100.00	$ 100.00
PVC pipes/connector – challenge field		Home Depot	$ 189.00	$ 189.00
Wire (12g, 18g)		Andymark	$ 30.00	$ 30.00
Victor SP Speed Controller (am-2855)	5	Andymark	$ 300.00	$ 300.00
12 gauge red black bonded wire, 25ft length (am-0904)	5	Andymark	$ 87.50	$ 87.50
3-wire PWM cable, 12 inches (am-0693)	5	Andymark	$ 13.75	$ 13.75
5 Amp Snap Action Breaker (am-2096)	5	Andymark	$ 30.00	$ 30.00
10 Amp Snap Action Breaker (am-2097)	5	Andymark	$ 30.00	$ 30.00
PWM Connector Kit (am-2817)	1	Andymark	$ 50.00	$ 50.00
Plastic case/protector	1	Lowes	$ 10.00	$ 10.00
25A Fuse	1	Autozone	$ 5.00	$ 5.00
Color Camera – underwater fish, wide angle	2	eBay	$ 245.00	$ 245.00
USB Camera – pipe inspection	2	Amazon	$ 25.00	$ 25.00
Pool Rental	1	Bluwater Scuba	$ 500.00	$ 500.00
Banana clips/connectors	2	Amazon	$ 5.00	$ 5.00
Misc. Supplies			$ 50.00	$ 50.00
Donations / Loans				
Dive Computer/Depth Gauge	1	Bluwater Scuba	$ -	$ 50.00
Dive Compass	1	Bluwater Scuba	$ -	$ 50.00
Talon SR speed controller	1	iLite Robotics	$ -	$ 50.00
FRC Power Distribution Board	1	iLite Robotics	$ -	$ 150.00
12V Marine Battery	1	Personal	$ -	$ 50.00
Flexseal	1	Personal	$ -	$ 20.00
VEX Cortex microcontroller	1	Systemic Solutions	$ -	$ 200.00
VEX wireless joystick	2	Systemic Solutions	$ -	$ 100.00
VEX batteries	10	Systemic Solutions	$ -	$ 50.00
PVC pipe & connectors	100+	Systemic Solutions	$ -	$ 100.00
Laptop – RobotC	1	Systemic Solutions	$ -	$ 500.00
Bilge pumps/motors	6	Systemic Solutions	$ -	$ 150.00
B&W fish cameras	4	Systemic Solutions	$ -	$ 200.00
Tools		Systemic Solutions	$ -	$ 100.00
Electrical tape	2	Systemic Solutions	$ -	$ 10.00
Soldering iron	1	Systemic Solutions	$ -	$ 100.00
Storage boxes	4	Systemic Solutions	$ -	$ 50.00
			$ 1,670.25	$ 3,600.25

LESSONS LEARNED

Technical

- Standard propellers not very good - Vertical thrusters were not working- solution 3d printed our own
- X drive spins really well but goes forward really slow – solution decided to change to tank drive because it was easier for our drivers to understand how to use the controller to maneuver the ROV.
- Multiple real-time videos on a single screen/monitor is hard to do using just software

Interpersonal

- More time designing before building
- Start sooner
- More research into existing designs
- More people
- Need stronger project management and time management skills
- Need better collaboration tools

FUTURE IMPROVEMENTS

ROV

- Design a better navigational system - navigating by cameras alone -REALLY HARD!
- Multiple videos on single computer screen, perhaps use Robo Realm.
- Mount the cameras on motors so they can pan and zoom
- Redesign Tether, perhaps replace with just a single set of power cables and video cables. The current tether has too many wires, is too big, and too heavy.
- Use waterproof quick disconnect electrical connectors

Company/Team

The team faced many challenges during our short MATE build season. Our top lesson we learned is that we needed more time and more people. Next year we will need to start earlier and identify other students who have skills which we did not have on the team this year.

Additionally we will be working to improve the Project Management Office. In general, the PMO was not very effective. Construction of the ROV took priority for our meeting times due to our Post getting a late start with the project. The PMO was seen by the project team as taking needed time away from construction. The PMO had a difficult time proving its value to the team.

However, we do believe that the team learned about the purpose of a PMO and that we were able to identify key milestone dates to help us organize our time. In the future, it would help to have more support from the team and more responsibility given to the PMO.

TEAM BIOGRAPHIES & REFLECTIONS

Most rewarding part of MATE project

- First time we drove ROV underwater
- Designing the ROV
- The discover scuba session we held where we all got to get in the water in scuba gear
- First time we had models of working manipulators

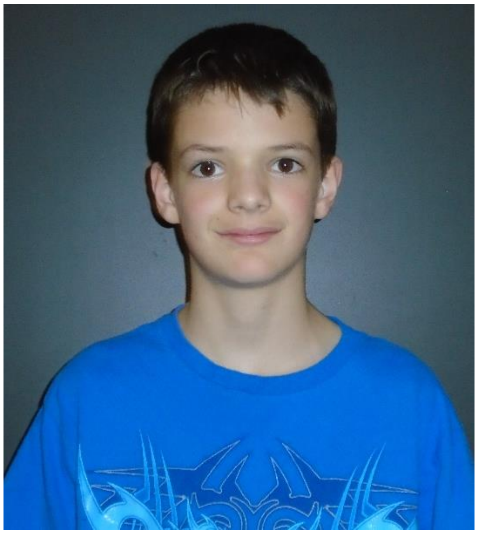
Daniel Becker: Guidance Specialist, 6th Grade, Rookie

Ben Clark: Manipulation Specialist, 9th Grade, Rookie

My name is Benjamin Clark. I am a freshman at Patriot High School. I have some robotics background. In the 7th grade I was in VEX Robotics. In the beginning of the 9th grade I was in Zero Robotics and almost made it to worlds. Now I am testing my skills in the field of ROVs.

This is my first year in MATE.

Josh Clark: Chassis Engineer, 5th Grade, Rookie

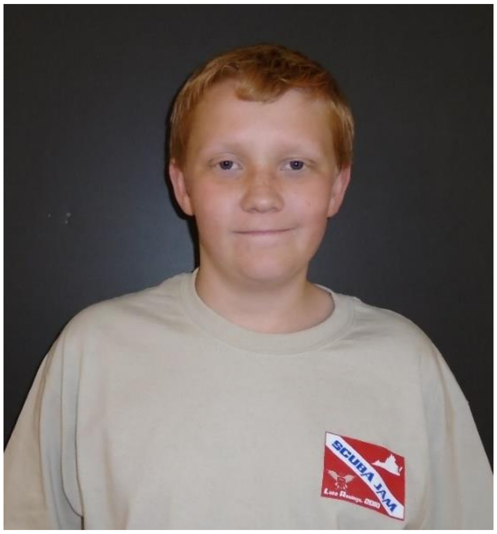


My name is Josh Clark. I am a 5th grader at Bristow Run Elementary School. I have some robotics backgroud, being that I have participated in VEX robotics and in First Lego League. This is my first year in MATE.

Harry Davidson: Chief Navigator, Programmer, 8th Grade, Rookie

Hi, my name is Harry Davidson. I'm in the 8th grade at Gainesville Middle School. I just completed my 3rd year in VEX robotics and our team came home with the Community Award from the VEX Worlds competition held in Louisville KY. Prior to VEX I participated in the First Lego League robotics. This is my first year participating in the MATE robotics competition. Mid-season of my 7th grade year I found my calling to be a programmer. This year in my spare time I created, designed and executed a video game I named "Hoop Rider". It was quite a challenge, but I enjoyed it. As an adult I hope to be able to use my programming skills to be very successful.

Kyle Jarrett: Chief Safety Inspector, 8th Grade, Rookie



Hi, my name is Kyle Jarrett and I am an 8th grader at Gainesville Middle School. I have been on robotics teams since I was in the fourth grade – starting with First Lego League (FLL) and then VEX robotics. In 7th grade I competed in a regional Seaperch ROV competition. I know I want to be an engineer.

This is my first year competing in MATE.

Lauren Jarrett: PMO, Director of Buoyancy, 5th Grade, Rookie

My name is Lauren Jarrett and I am a 5th grade student at Bristow Run Elementary School. I'm interested in robotics because I enjoy the competitions, enjoy working with my team, working on my robot, and thinking a little harder than usual.

I also like my engineering notebook and designing my ideas.

I started robotics when I was in 3rd grade on a FLL team and my dad was my coach. I didn't like programming but I did like to make notes and that's why I take an interest in our engineering notebook.

This is my first year competing in MATE.

Matthew Rao: Executive Propulsion Expert, 6th Grade, Rookie

My name is Matthew Rao. I am 12 years old and I'm in 6th grade at Gainesville Middle School. This is my first year participating in the MATE robotics competition, but I have actively participated in the engineering and robotics field for 4 years. My aspiration as an adult is to be an aeronautical engineer, possibly with a major firm like Rockwell Collins, Lockheed Martin, or Northrop Grumman.

This is my first year competing in MATE.

Ethan Repesh: Manipulation Specialist, 6th Grade, Rookie

My name is Ethan Repesh. I am in the sixth grade. This is my first time doing MATE Robotics. I really like to make things and see how they work. I decided to join the manipulator team. From there I helped my team design and create the manipulators. I can't wait for the competition.

This is my first year competing in MATE.

Luke Sheakley: PMO, Control Specialist, 6th Grade, Rookie

My name is Luke Sheakley and I live in Bristow, VA. I am in 6th grade at Gainesville Middle School. My hobbies are playing golf, playing the piano, flying RC air planes, and robotics. I joined MATE because I wanted to have the experience of making an underwater ROV and I also enjoy building robots to do difficult and real life tasks. I have had previous experiences of working with robots before with FLL and VEX. This is my first year competing in MATE.

ACKNOWLEDGEMENTS

Sponsors – Explorer's Inc.

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APPENDIX A: ROBOTC – CODE

x-Drive

```
#pragma config(Motor,  port2,           frontRight,    tmotorServoContinuousRotation, openLoop)
#pragma config(Motor,  port3,           backRight,     tmotorServoContinuousRotation, openLoop, reversed)
#pragma config(Motor,  port4,           frontLeft,     tmotorServoContinuousRotation, openLoop)
#pragma config(Motor,  port5,           backLeft,      tmotorServoContinuousRotation, openLoop)
#pragma config(Motor,  port9,           lerticals,     tmotorServoContinuousRotation, openLoop, reversed)
//*!!Code automatically generated by 'ROBOTC' configuration wizard
!!*//

/*+++++++++++++++++++++++++++++++++++++++++++++| Notes
|+++++++++++++++++++++++++++++++++++++++++++++
Mecanum Drive with Deadzone Thresholds
- This program allows you to remotely control a robot with mecanum wheels.
- The left joystick Y-axis controls the robot's forward and backward movement.
- The left joystick X-axis controls the robot's left and right movement.
- The right joystick X-axis controls the robot's rotation.
- This program incorportes a threshold/deadzone that allows very low Joystick values
to be ignored.
This allows the robot to ignore values from the Joysticks when they fail to center at
0,
and provides a margin of error for the driver when they only want the robot to move
in one axis.

[I/O Port]          [Name]              [Type]                [Description]
Motor Port 2        frontRight          VEX Motor             Front Right motor
Motor Port 3        backRight           VEX Motor             Back Right motor
Motor Port 4        frontLeft           VEX Motor             Front Left motor
Motor Port 5        backLeft            VEX Motor             Back Left motor
Motor Port 9        vertical            VEX Motor             vertical motor
--------------------------------------------------------------------------------------
-------------*/

task main()
{
	//Create "deadzone" variables. Adjust threshold value to increase/decrease
deadzone
	int X2 = 0, Y1 = 0, X1 = 0, threshold = 15, fr, fl, bl, br;

	//Loop Forever
	while(1 == 1)
	{
		//Create "deadzone" for Y1/Ch3
		if(abs(vexRT[Ch3]) > 25)
			Y1 = vexRT[Ch3];
```

```
            else
                   Y1 = 0;
            //Create "deadzone" for X1/Ch4
            if(abs(vexRT[Ch4]) > threshold)
                   X1 = vexRT[Ch4];
            else
                   X1 = 0;
            //Create "deadzone" for X2/Ch1
            if(abs(vexRT[Ch1]) > threshold)
                   X2 = vexRT[Ch1];
            else
                   X2 = 0;
            //var
                   fr = Y1 - X2 - X1;
                   fl = Y1 + X2 + X1;
                   br = Y1 - X2 + X1;
                   bl = Y1 + X2 - X1;
            //Remote Control Commands
            motor[frontRight] = fr + 5;
            motor[backRight] = br + 5;
            motor[frontLeft] = fl + 0;
            motor[backLeft] =  bl + 15;
            motor[lerticals] = vexRT[Ch2];
      }
}
```

Tank Drive

```
#pragma config(Motor,  port2,           FrontRight,    tmotorServoContinuousRotation, openLoop)
#pragma config(Motor,  port3,           BackRight,     tmotorServoContinuousRotation, openLoop, reversed)
#pragma config(Motor,  port4,           FrontLeft,     tmotorServoContinuousRotation, openLoop)
#pragma config(Motor,  port5,           BackLeft,      tmotorServoContinuousRotation, openLoop, reversed)
#pragma config(Motor,  port8,           ForwardReverse, tmotorServoContinuousRotation, openLoop, reversed)
#pragma config(Motor,  port9,           Vertical,      tmotorServoContinuousRotation, openLoop)
//*!!Code automatically generated by 'ROBOTC' configuration wizard               !!*//

//Explorer Post 1882 - MATE ROV - Tank Controls

task main()
{

while (1==1)
{
//Tank controls
	motor[FrontRight]=vexRT[Ch2];
	motor[BackRight]=vexRT[Ch2];

	motor[FrontLeft]=vexRT[Ch3];
	motor[BackLeft]=vexRT[Ch3];

//Control vertical thruster on 2nd transmitter
	motor[Vertical]=vexRT[Ch2Xmtr2];

//Control forward/reverse thruster
//forward when both tank controls both forward
//reverse when both tank controls reverse

if((vexRT[Ch3] & vexRT[Ch2]) >63.5)
	{
	motor[ForwardReverse]=vexRT[Ch2];
	}
	else
	{
		motor[ForwardReverse]=0;
	}
	if ((vexRT[Ch3] & vexRT[Ch2]) <0)
	{
	motor[ForwardReverse]=vexRT[Ch2];
	}
	else
	{
		motor[ForwardReverse]=0;
	}
} }
```

APPENDIX B: VEX CONFIGURATION

Vex Cortex - Mapping

Motor Port	Channel/Button	Program Name	Notes
1 (2 wire)			
2	Ch2 – xmtr1	FrontRight	
3	Ch2 – xmtr1	BackRight	
4	Ch3 – xmtr1	FrontLeft	
5	Ch3 – xmtr1	BackLeft	
6			
7	Ch2 – xmtr2	Forward/Reverse	
8	Ch2 – xmtr2	Vertical	
9			
10 (2 wire)			

Vex Joystick - Main Controller Mapping

Btn 7U ________________

Btn 7D ________________

Btn 7L ________________

Btn 7R ________________

Ch 4

Ch 3 __LEFT THRUSTER___

Btn 8U ________________

Btn 8D ________________

Btn 8L ________________

Btn 8R ________________

Ch1

Ch2 RIGHT THRUSTER

Btn 6U ________________

Btn 6D ________________

Btn 5U ________________

Btn 5D ________________

VEX Joystick Partner Controller Mapping

Btn 7U ____________________

Btn 7D ____________________

Btn 7L ____________________

Btn 7R ____________________

Btn 8U ____________________

Btn 8D ____________________

Btn 8L ____________________

Btn 8R ____________________

Ch 4 ____________________

Ch 3 ____________________

Ch1 ____________________

Ch2 VERTICAL THRUSTERS

Btn 6U ____________________

Btn 6D ____________________

Btn 5U ____________________

Btn 5D ____________________

APPENDIX C: COMPANY SPEC SHEET

EXPLORERS, INC.

About Us

Established in March 2015, Explorers Inc. is a wholly owned subsidiary of Engineering & Technology Post 1882. Explorer Post 1882 is a co-ed STEM focused engineering club for young men and women, headquartered Haymarket Virginia. Explorers Inc. is 1,160 miles from the 2015 international competition in Newfoundland Canada. This is the team's first time competing in the MATE competition.

- *Benjamin Clark: Guidance Navigation & Control (GNC), Manipulators, 9th Grade*
- *Kyle: Propulsion, Manipulators, 8th Grade*
- *Lauren: Project Management Office (PMO), Sales & Marketing, 5th Grade*
- *Daniel: GNC, 6th Grade*
- *Josh: Chassis, Manipulators, 5th Grade*
- *Luke: PMO, Sales & Marketing, 6th Grade*
- *Matthew: Propulsion, Chassis, 6th Grade*
- *Ethan: Manipulators, GNC, 6th Grade*
- *Harrison: GNC, 8th Grade*

Team from left to right

Inaugural launch

Explorer Mark II—2015 MATE Mid-Atlantic

ROV Highlights

- Octagon Chassis
- Custom 3D printed propellers
- X-Drive, 6 thrusters
- VEX Cortex microcontroller & wireless joystick driver controls
- Compass
- 5 video cameras
- Dimensions: 23"x23"x16"
- Weight: 8lbs

Safety Features

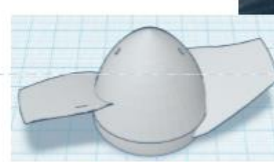
- Power Distribution board
- 25A main fuse and individual 5A/10A fuses thruster
- Custom 3D printed thruster shrouds
- Waterproof wiring
- Tether spool

Cost ($1700)

- Game Field Set-up: $200
- Color Digital Cameras: $245
- Electronics/Wiring: $600
- Pool Time: $500
- Misc. Parts: $100
- DONATIONS: PVC, B&W underwater cameras, Power Distribution Board

Corporate Partners

- Stellar Solutions, QBE Global
- Systemic Solutions, BluWater Scuba



Propeller CAD model

Explorer Mark II

APPENDIX D: EXPLORER POST 1882 – ABOUT US

EXPLORER POST 1882

STEM

ENGINEERING TOMORROW

SCIENCE * TECHNOLOGY * ENGINEERING * MATHEMATICS

Explorer Post 1882/Club 42 is a Learning For Life Engineering and Technology Explorer Post & Club in Prince William County Virginia. We explore a variety of fields in Engineering and Computer Sciences in order to help young adults make educated decisions on future career possibilities. We also engage in competitive robotic challenges, take field trips to area employers and facilities, and provide STEM community outreach programs.

VISION:

Our vision is to create a program and environment which explores the career opportunities engineering, science, technology and math afford young adults. To inspire middle and high school students to love problem solving and critical thinking through the hands-on exploration of STEM. To inspire youth to become lifelong learners and explorers.

ACTIVITIES:

- Project Teams - Engineering Challenges
    - The Explorer Post/Club is broken into several project teams each of which focuses the efforts of small groups of students on a single engineering challenge or competition.
    - VEX Robotics
    - Seapearch
    - Zero Robotics
    - First Robotics
    - TARC (rocketry)
- Engineering Guest Speakers
    - Each month the Post/Club invites practicing engineers to talk to the youth about their engineering career/field of study
- Engineering Field Trips
    - Periodically the club takes trips to see engineering in action. Trips include NASA's Goddard Space Facility, Wallop Island, Micron's Semiconductor factory, VW's Assembly plant, and the like
- Community Outreach
    - The Post/Club offers/sponsors community (schools, Boy Scouts, Cub Scouts, Girl Scouts) STEM activities such as Robotics Merit Badge, Sumo Robots, and the like

About Learning For Life

Learning for Life offers programs designed to support schools and community-based organizations in their efforts to prepare youth to successfully handle the complexities of contemporary society and to enhance their self-confidence, motivation, and self-esteem. The programs focus on character development and career education. Learning for Life programs help youth develop social and life skills, assist in character and career development, and help youth formulate positive personal values. It prepares youth to make ethical decisions that will help them achieve their full potential.