2015

University of Massachusetts – Dartmouth

I.D.E.A. CLUB – A.R.C.T.I.C.

STEVEN BROWN – MENTOR

BRANDON MACDONALD – PRESIDENT

STACY CORREIA – VICE PRESIDENT

EDDIE PURTELL – TREASURER

NICOLE GREGORY - SECRETARY

Introduction

Abstract

St. John's, Newfoundland is home to Newfoundland's Marine Institute and the National Research Council's Ocean, Coastal and River Engineering (OCRE) and their world-class facilities. Many scientists working in polar environments as well as companies involved in oil and gas operations on the North Atlantic continental shelf are headquartered there, and many others have offices there.

Their research has been prominent for years, as the Arctic conditions under survey will affect human life. For humans that live in the arctic, everyday obstacles include very low temperatures and constant darkness. However, conditions are changing. Many non-natives are being attracted by recent discoveries of oil, minerals, and diamonds in Arctic areas. For non-Arctic residents, the impacts are present mainly in the form of climate and weather. Although the discovery of how the Arctic conditions impacts temperatures and precipitation in the mid-latitude is still in the early stages, it is apparent that it is a dominant feature in the matter by the changes in the reflectivity of the land and ocean surfaces or in ocean currents possibly resulting from different conditions in the Arctic. These studies should lead to more reliable weather forecasts, as well as teach us more about how the Arctic influences the global climate and allow us to manage and use the natural resources of the Arctic.

From brainstorming and prototyping, to troubleshooting and producing the final design, the 2015 MATE ROV Competition has tested I.D.E.A. Club's abilities in many areas. As members of the UMASS Dartmouth I.D.E.A. Club, our task at hand is to create a remotely operated vehicle that has the ability to conduct *Science Under the Ice*, *Subsea Pipeline Inspection & Repair* and *Offshore Oilfield Production & Maintenance*. This will consist of counting species, sampling organisms, deploying an instrument, collecting data about an iceberg, replacing a corroded section of oil pipeline, preparing a

wellhead, testing the grounding of anodes on the “leg” of an oil platform, measuring the height of a wellhead and controlling the flow of oil through a pipeline.

Company Abstract

The I.D.E.A. Club is a UMASS Dartmouth student run, engineering based, non-profit organization that allows students to collaborate and learn by doing. We believe it is one of the few organizations on campus that allows students to use the intellectual knowledge that they have gained in a creative and innovative manner. 2015 is the I.D.E.A. Club’s fifth year competing in the M.A.T.E. R.O.V. Competition. As part of the Explorer Class, we have competed at the international level in Michigan (2014), Florida (2012), Texas (2011), and Hawaii (2010). The club’s returning members include Steven Brown (mentor), Brandon MacDonald (president), Stacy Correia (vice president), and Eddie Purtell (treasurer). Our new members include Nicole Gregory (secretary), Aaron Jesus, Stephen Kolvek, Joseph Hazel, Diarny Fernandes, Adam York, Michael Benson, and Marc Carreira.

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Design Rationale

Overview

Based on the results of previous years, we decided that we needed to rethink our design process. We started with a simple brainstorm. We discussed the missions with all of our members and asked everyone to jot down their ideas. After examining everyone's proposals, we chose a suggestion and began to imagine it. We planned out our best approach and began to bring it to life. We created prototypes, tested them and eventually designed the final product.

In order to build a competitive ROV, our team unanimously decided that ARCTIC had to be as compact, modular and high-quality as possible. Our first attempt at this was purchasing professional thrusters and waterproof connectors. These factors have concerned us in the past and had a simple enough solution, so we decided to correct them as early on as possible. We have also decided that we should follow MATE's suggestions and "Keep It Simple, Students!" by keeping our tools as simple as possible. The more complex our tools are, the greater the possibility of an error occurring. Unfortunately, we are still struggling with one of our past goals – to create a frame so well designed that it could be reused in future years. Hopefully this year's design will be secure enough to fulfill our wishes.

Electronics

Main Control Unit

For the main control unit (MCU) of the ROV, we decided to use the versatile Arduino Mega 2560, or "the Mega" for short. This is an inexpensive and flexible microprocessor, possessing ample processing power, IO (input/output), and communications for the requirements. The Mega has 54 digital IO ports, 15 of which provide PWM (pulse width modulation) output. Additionally, 16 pins which are tied to an ADC can also be used as digital IO. The Mega also has support for 4 simultaneous serial port connections, a feature that offers a great advantage for debugging. The Arduino platform also facilitates rapid prototyping, as the ATmega chip, which is at the heart of the Mega, allows reprogramming without penalty. That is, programs can be written, uploaded, and tested in a matter of minutes. This presents us the opportunity to edit the code at a whim, without costly hardware changes. This makes the Arduino a hacker's favorite thing, among many. As such, the Arduino Mega2560 was chosen as the main control unit.

Microcontroller	**ATmega2560**
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

*Table 1 - Arduino Mega2560 Summary - From **http://arduino.cc/en/Main/ArduinoBoardMega2560***

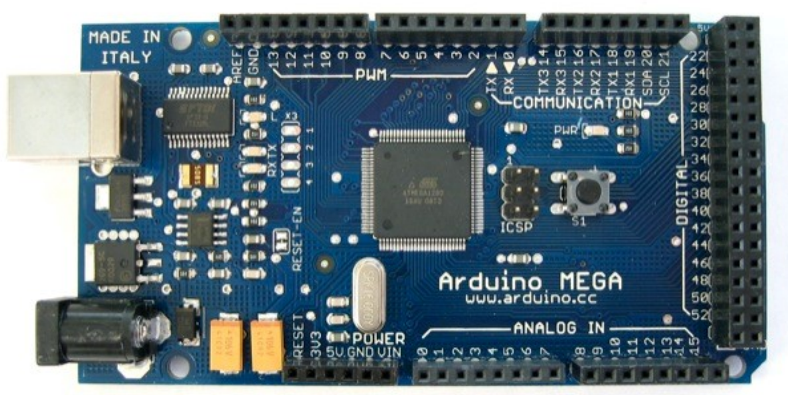


Figure 1 - Image of Arduino Mega2560 - Via arduino.cc

A PCB was designed to breakout all the pins on the Arduino, and to group them according to function and destination. These functions are as follows:

- Thruster control (each addressed as a servo, needs one signal pin, enable pin, and a ground pin)
    - Eight groups of three pins (one for signal, one for ground, and enable) allowing for up to 8 thrusters to be controlled
- Tool control (four pins necessary, one for GPIO for direction, one Fault, and one Chip Select, and one PWM for speed)
    - Two groups of 10 pins (five groups of the four pins per tool) allowing for independent control of up to five separate high-current tools
- Servo Power boosters (four digital pins per board)
    - Four groups of four pins allowing for 16 servos to be powered externally from the Mega
- Sensor input (one ADC pin per sensor, also Vcc and GND)
    - A 75A current sensor occupies one location, allowing the operator to determine what amperage the ROV is drawing
    - Pressure transducer for accurate depth readings is attached to a second location to allow the operator to determine the current depth of the vehicle
    - Conductivity sensor is attached to one of these pins
    - Three leak sensors to determine if a leak occurs
- Communication breakout pins (Rx, Tx, GND)
    - Communication to the surface over tether with use of an RS-232 circuit
    - Accelerometer & Compass for the operator to know current heading and angle
    - Power Board communication to receive feedback on power condition and to enable/disable power

Additionally located on the PCB is a RS-232 circuit, which converts TTL level signals (0V-5V) from the Arduino into RS-232 level signals (up to +/- 15V), allowing for longer cable length with lessened signal loss. The output from this circuit is connected to a header to allow easy connection to the tether wires.

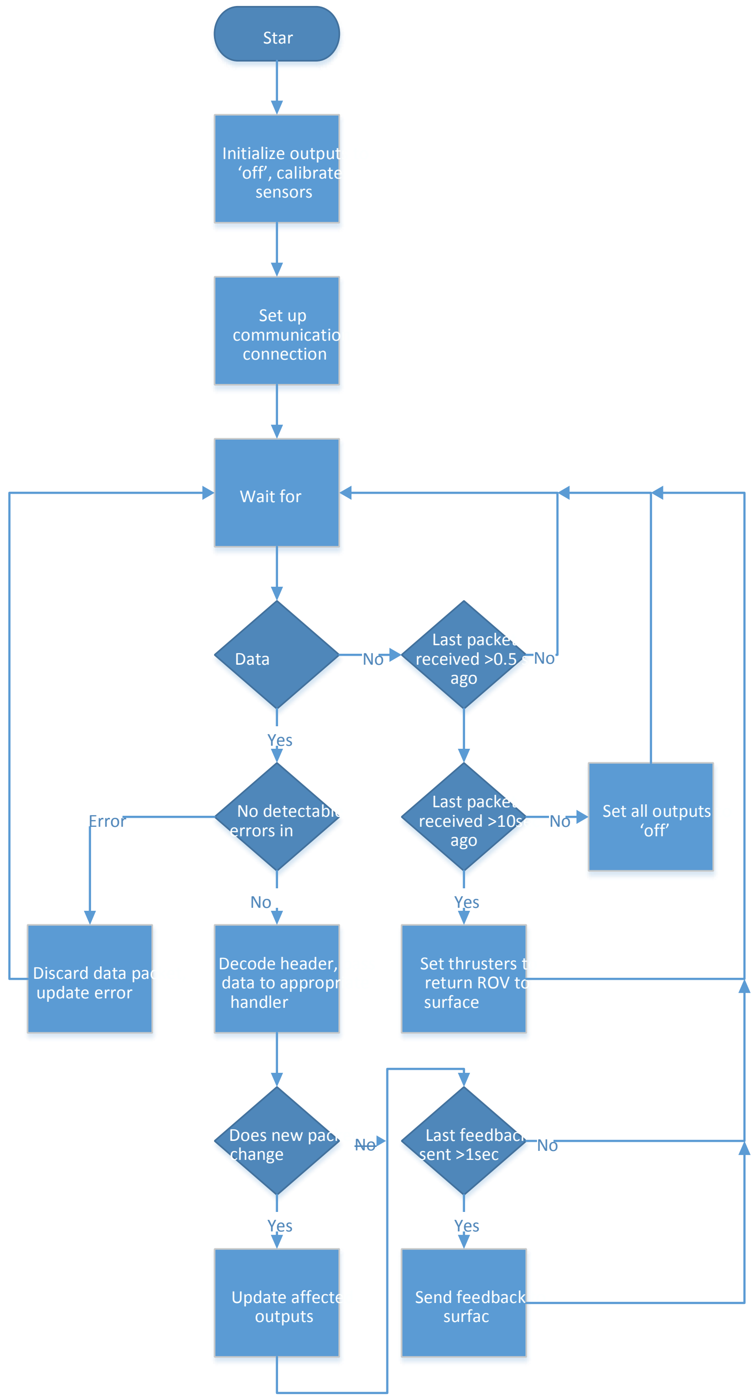


Figure 2 - Master Control Unit software flow

Tool Control Board

The Tool Control Board (TCB) is a board allowing bi-directional control of a brushed DC motor, providing a 30A max continuous current, when adequate cooling is supplied. This is achieved through 5 discrete circuits on the PCB. Each circuit consists of a surface mount integrated H-bridge motor driver (VNH2SP30-E). This small chip utilizes PWM and direction pins to provide power to a brushed DC motor.

Input to the TCB is the two 2x5 connector cables from the MCU board. Four pins (one for speed [PWM], chip select, Fault, and direction [GPIO]) are used to control each discrete motor driver circuit. The speed pin is tied directly to the PWM pin on the H-bridge chip. The direction pin is routed to a hex inverter and to one IN pun on the H-bridge chip. The inverted direction output from the hex inverter is tied to the other IN pin on the H-bridge chip. This is required for correct operation of the chip, as outlined in the table below:

Table 2 - Truth Table for Operation

IN_A	IN_B	Input	Operating Mode
1	1	--	Brake to V_{CC}
1	0	PWM	Clockwise
0	1	PWM	Counter-Clockwise
0	0	--	Brake to GND

Figure 3 - VNH2SP30-E Chip

This chip can allow a maximum continuous output current of 30A with proper cooling. Most tools that have been previously designed for the ROV have drawn a maximum of around 9A, so these chips have plenty of overhead. Without proper cooling, these chips are rated for 14A continuous, still more than enough to satisfy the current requirement by most of the ROV's tools. Still, to be safe, two 80mm fans were mounted to provide airflow across these chips to allow for higher current draw, if the need arises.

As a fault monitor, a simple LED was tied to the 'Fault' pin of the H-bridge chip. This pin needs to be pulled high to enable the chip, and when it encounters a fault, the chip pulls the pin low. This allows us to put a LED (with current limiting resistor) in parallel with a pull-up resistor, tied to the Enable/Fault pin such that the LED lights up when the chip faults.

Main power to the TCB is provided through a large terminal block rated for 30A continuous. Since it is highly unlikely that any more than one of these tool circuits will be on and providing max allowable current to its respective tool, 30A was considered a safe rating for the input terminal block. The +12V power provided by this routed to the V_{IN} pins of the H-bridge chips, as well as to a voltage regulator, which provides +5V for the use with the hex inverter and the +5V levels required on the enable pins of the H-bridge chips.

Surface Control Board

For a user interface, the Raspberry Pi is used with a custom Linux image. The modified ArchLinux image boots into a Python script to provide user control of the ROV via joystick. The Raspberry Pi is an open-source, low-power and inexpensive computer on a chip. This was chosen, as previously stated, due to its low cost as well as its size. The same approximate size of a credit card, the low-power Raspberry Pi is still fast enough to process user input while being compact to better integrate with the portable ROV control system. Two models of the Raspberry Pi exist, the Models A and B. Model B is identical to the A, save for two USB ports whereas the A has one, and the inclusion of an Ethernet port. The Model B was selected for use, mainly due to USB requirements (one USB port for communication with the Arduino, and one for the joystick).

System on a Chip	Broadcom BCM2835
Processor Speed	700MHz (O.C. to 1Ghz)
Memory	512MB
Connectivity	2xUSB2.0; 100Mbit Ethernet
Video	Composite; HDMI
Power	MicroUSB, 5V

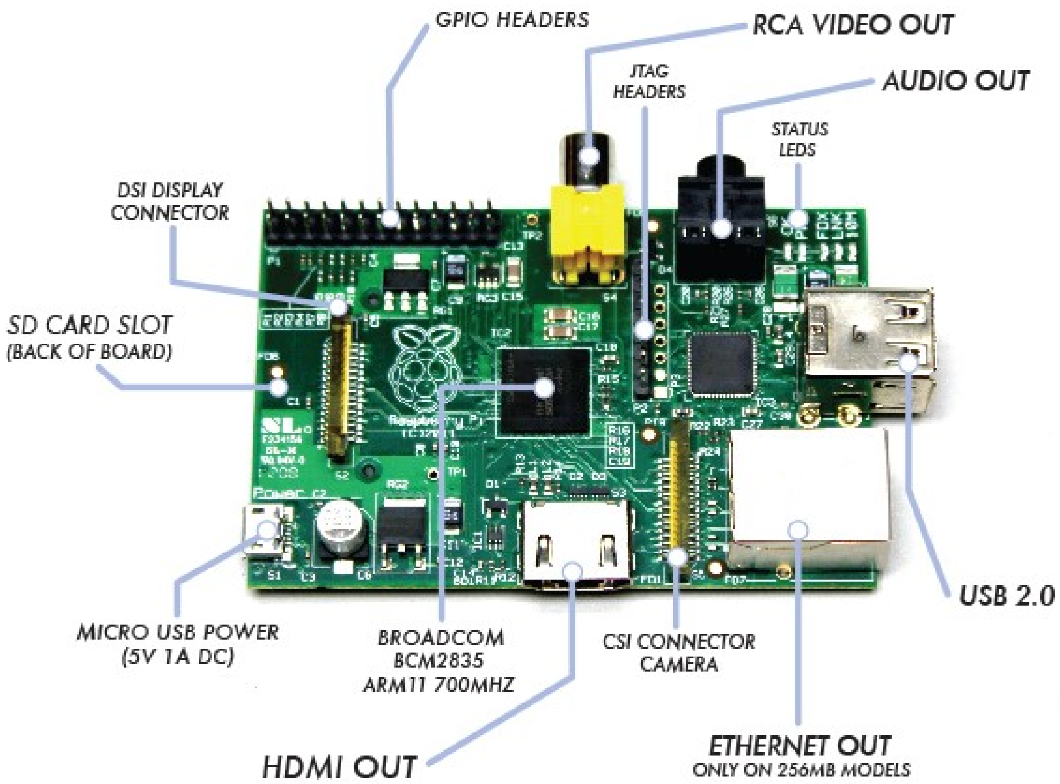


Figure 4 - Image of Raspberry Pi Model B - Via pcmag.com

In addition to the Raspberry Pi, the Surface Control Board (SCB) integrates with another Mega, which provides communications from the control system and links to the tether for communications with the MCU on the ROV. On the left side of the board is the tether input. This provides +12V power from the ROV to power the SCB. Also on this connector are Tx and Rx for communications, as well as three camera feeds from the CMUX on the ROV. The three camera feeds are simply routed to three 1x2 pin male headers (signal and ground each) to be plugged into a monitor. The Tx and Rx lines are routed to a RS-232 chip for decoding, and the output of this chip is tied to a Tx1 and Rx1 of the Mega. Again, Tx1 and Rx1 were chosen to allow Tx and Rx to be used for USB communications with the controlling computer. The +12V power input from the tether is tied to the V_{IN} pin of the Mega, as well as an LED to provide a visual indication to the pilot that the board is receiving power from the ROV. An additional LED provides a visual indication that the surface Mega is operating correctly and is stepping the incoming +12V to +5V levels for use with any digital or analog sensors to be used on the surface.

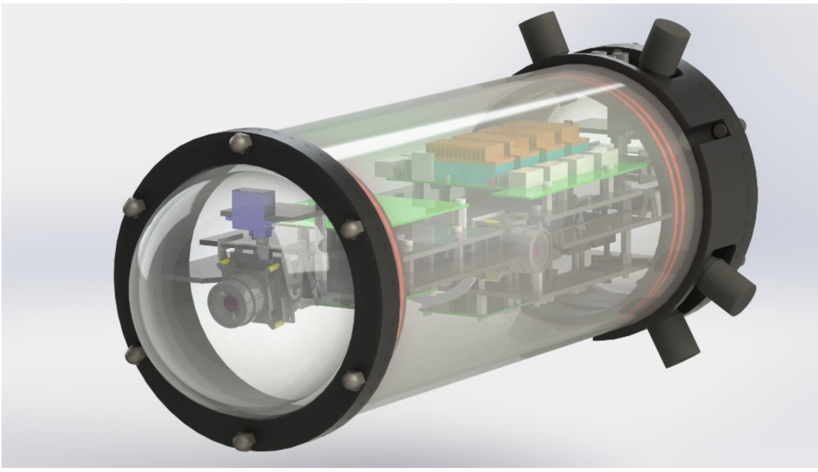


Figure 5 – SolidWorks Image of Electronics Tube

Ten analog input pins are broken out to ten 1x3 pin male headers on the PCB to be used for any control that cannot be achieved through our joystick attached to our control system. Uses for this include the output of potentiometers which control the position of the robotic arms on the ROV. This allows a modular approach to control of the ROV, instead of having one joystick control everything. Further, 12 GPIO pins are broken out in 12 1x2 pin (GPIO for ground) male headers to be used as inputs or outputs for items such as pushbuttons (for example, for our camera selector). All of the Mega's PWM outputs are also broken out into male headers to be used as necessary. The initiative to provide a platform which can be reused in future years, while incorporating future expendability, was the motivation to breaking out various pins that may not have a specific purpose at this point in time.

Mechanical

As stated in the Overview, we used a multi-step approach in order to maximize the efficiency of the design process. This allowed our team to envision the final product earlier on and minimize the number of revisions we would make to the ROV. We sketched out our brainstorms on paper and drew them up in SolidWorks. If a part was a little more complex, we would create a prototype before we started on the final product to assure that it would work as we planned.

Connector Flange

The connector flange is a custom made part that allows for the waterproof connectors to be connected around the electronics and buoyancy tube. The big advantage of having this part is, unlike most ROV companies that use tubes as the housing locations, this ROV has a tilt pan camera on the back as well as the front, while utilizing only one tube instead of two. This keeps the electronic components consolidated. The connector flange was first 3-D printer using a high strength ABS plastic. After printing all of the connector holes, mounting locations were milled to the specific diameters and a lathe was used to machine the o-ring grooves. Once machining was finally complete, the part was sealed using a specialty marine-grade epoxy that was painted on and pulled deep into the part using a vacuum chamber. This ensures that it will be watertight.

Figure 6 - Image of Connector Flange

Buoyancy

Instead of using standard foam and air bladder buoyancy packages, this ROV gets its buoyancy from a 6.5” inner diameter, 0.25” thick acrylic tube that is mounted through the center of the ROV’s frame. The ends of the tube are sealed with custom o-ring flanges and camera half spheres. What is nice about this is, this tube also serves as our electronics housing to save space elsewhere on the ROV. It acts as a two-in-one part. All of the components are installed on the ROV frame, including the electronics, thrusters, waterproof connectors, and assorted hardware. This essentially makes up the core of the ROV. On top of all of this, the buoyancy package still provides 8 to 9 pounds of extra buoyancy to hold the weight of all of the tools needed for the task at hand. Another positive aspect of having the buoyancy package mounted centrally is that it allows for a more even control of roll movement from the thrusters.

Thrusters

Purchased from Crust Crawler, eight 400HFS-L hi-flow thrusters are used to propel ARCTIC through the water. 4 of the thrusters are used for vertical thrust and 4 are used for horizontal thrust, as well as turning the vehicle. Each supplies a maximum of 22.24 Newtons of thrust. By incorporating 4 vertical thrusters, we were greatly advantaged. By positioning each vertical thruster in a corner, we are able to lift uneven loads that others may find difficult. We can accomplish this by adjusting the speeds of the thrusters as needed to keep ARCTIC level when lifting. This also gives the pilot the ability to control pitch and roll which can be useful during tricky maneuvers.

Figure 7 - Image of 400HFS-L UROV/ROV Thruster

Frame

A lot of thought went into creating the frame for this model of the ROV. The most important feature of our ROV for this specific competition was that it needed to be compact enough to be able to easily fit through the 75cmx75cm holes in the ice. In order to accomplish this, the thrusters were all mounted on the inside of the frame and there is space where tools can be mounted internally. We chose the unique shape of the frame logically. Instead of standard square sides, large 45 degree angles were added to the corners to assist the ROV's pilot in maneuvering it through the openings in the ice. Big windows were cut into the two frame sides to allow for the ROV pilot to be able to see out the sides of the ROV, as two cameras are mounted on a tilt servo in the center of the buoyancy tube. There are also many conveniently located mounting locations along the bottom-most part of the frame, allowing for different tools to be mounted in many orientations. The main cross-members of the ROV's frame are in the shape of a large X. This is to hold the centrally mounted buoyancy package. This also keeps the cross-members from interfering with the vectored thrust, or tools mounted on the front or back of the frame.

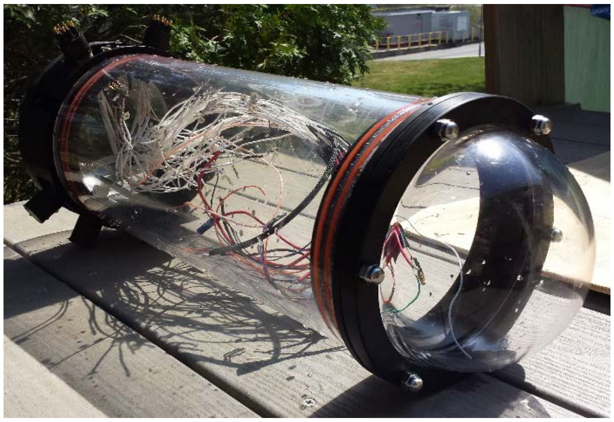


Figure 8 - Image of Electronics Tube

The horizontal tool cross-members located at the bottom of the ROV features two half circles cut out along the sides. This provides a place for two of our main tools to be mounted within the interior of the frame, as opposed to the exterior. These tool locations can be viewed by the two center cameras mounted within the tube. There is a center hole in this cross-member to allow the pilot to see directly below the ROV using one of the center mounted cameras. This cross-member features many locations for easy tool mounting. There are two smaller cross-members across the top of the frame. These have slots cut into them, intended to act as handles, simplifying the transportation of the vehicle.

The frame was made using high density polyethylene (HDPE). This material was selected because, in water, it is slightly positively buoyant. This feature is beneficial in offsetting some of the hardware weight. This material is also very simple to machine, and does not absorb water. These parts were all cut using a water-jet cutting machine.

Cameras

A total of 4 cameras will be utilized and integrated into the design. The system has power provided from the main hub along with the data transfer from the cameras. The mounted cameras are high quality color HD Camera Modules. The camera specs consist of a vivid color video with a 1920x1080 resolution. The cameras output video using HDSDI. The cameras themselves are not waterproofed so each camera is mounted internally inside the electronics tube. Two cameras are mounted to pan tilt servos, one inside each of the two domes. This allows for precision viewing of the manipulator arm, any tools attached and excellent surveying of the props under the water.

The remaining two cameras are mounted on a tilt servo assembly in the center of the tube allowing view of any direction outside the ROV. This camera placement allows the ROV to have a complete representation of the placement of the ROV along with all of its surroundings.

On the surface, the video is converted from HDSDI into a HDMI connection, into a HDMI downscale, then brought into a splitter allowing each video to be viewed on the four dedicated monitors, or to be sent into a 4-to-1 Multiplexor to allow any of the four feeds to be displayed on a large external monitor. A joystick is used along with a camera selector button to move the two front and rear pan tilt cameras individually along with the center rotating camera.

Safety

Workshop Protocol

At UMASS Dartmouth, safety is the highest priority of any student project. I.D.E.A. Club strives to maintain a safe yet interactive environment for each of our club's members. At the beginning of each task, our members are briefed on what is expected of them while in the workshop. Because our students' well-being is most important to us, our club has a strict list of safety guidelines that we expect to be followed very closely.

First and foremost, we require education. Students are not allowed to use any tools or equipment that they have not been trained to operate. Each new member is instructed by a veteran member on the functions of each machine and will be guided through all first-time operations to ensure that they comply with all safety procedures. Any student operating machinery is required to wear closed-toed shoes and safety glasses at all times. All jewelry must be removed and all hand-wear is prohibited while operating any machinery where hands or fingers could be detained by dangerously moving parts. We also required that, prior to powering on any machinery, all team members are alerted of the tools being used, and the area is cleared to confirm a safe working environment.

We are strong believers in the "buddy system." Essentially, this means that no one works alone. This assists in the assurance that all team members are made aware of live wires and electrical testing, as well as things like hot soldering irons or moving mechanisms that could be hazardous. This practice has been proven to be an effective method of double-checking the safety of the work environment. This includes verifying that all loose cords are kept out of walkways and away from water, all tools are powered down and unplugged, and all supplies are returned to their residences, retaining a clean work station before everyone has left the workshop.

Finally, we urge our members to expect the unexpected. As we all know, Murphy's Law states that "*Anything that can go wrong, will go wrong,"* and we want our team to be prepared for whatever obstacles they may face. We know from experience that things don't always go as planned during testing. Developers don't always get the outputs that they expect. Things may turn on unexpectedly, refuse to turn off, and other undesired behaviors may occur. However, our precise application of observation, training and practice has fulfilled its purpose. These specific safety procedures were implemented to ensure the utmost safety while operating in the workshop and on the ROV, as well as to teach new members proper safety protocol. Our practices have prevailed, as we have remained accident free this year.

ROV Safety Features

In drafting our ROV, our team has focused on the safety of our students, our vehicle, and our surroundings. ARCTIC is designed to maintain the well-being of our members and our work environment during operation. The body was designed with smooth edges to assure no one would be cut on any sharp edges. We implemented electrical protection through various waterproofing techniques that insure that all electronics remain dry, keeping them operational and protecting both personnel and equipment from short circuits. If these efforts were to fail for some reason, our main control unit includes three leak sensors that will determine if a leak is occurring. This includes having our wires enter and leave the electronics box through custom made professional waterproof connectors that ensure tight sealed wire connections. ARCTIC also features professional thrusters that are equipped with motor shrouds to eliminate injuries caused by the propellers.

Logistics

Budget

This year, our ROV totaled approximately $12,500. Fortunately, we were able to raise about $5,000 through generous donations. We are also still in the process of receiving a donation from UMASS Dartmouth's College of Engineering which will assist with the travel funding.

Expenses		Fundraising	
Thrusters	$1,200.00	Boston Power	$500.00
Parts Machined	$900.00	ACP Waterjet	$1,000.00
Vision Systems	$1,500	Igus	$500.00
Electronic Boards	$400.00	Maplewood Mach.	$700.00
Electronic Component	$700.00	ATMC	$2,500.00
Hardware	$350.00	Crust Crawler	$100.00
Stock Material	$350.00		
Tools / Wires	$200.00		
Prototyping	$1,000.00		
Travel	$5,300.00		
Misc.	$520.00		
Total	$ 12,420.00	Total	$ 5,300.00

Contributing funds balance	
Total Expenses	$ 12,420.00
Total Fundraising	$ 5,300.00
Personal Contributions	$ 1,650.00

Figure 9 - Budget

Conclusion

Challenges

We're a student run, education based organization. That, in itself, is a challenge. We're all about student learning, and we leave it up to other students to do the educating. We want our members to be stimulated and inspired to achieve. We like to challenge our students to apply the physics, math, electronics, and engineering skills that they are learning in the classroom to solve real-world problems. It becomes an issue when we come across a matter that, as a group, we cannot find a solution to, but we don't allow these obstacles to curb our knowledge. We unite, take advantage of our resources, and figure it out – together.

One of I.D.E.A. Club's biggest challenges this year was the fact that we have such a young and inexperienced team. Almost half of our members are first year students at the University and have never experienced a M.A.T.E. competition before. While this was a great learning experience for our new members, explaining things and helping them understand it took away from the time that we could have been collaborating on ideas for the ROV. However, we realize that our efforts were not entirely futile; we hope we have done an adequate job of preparing our team for their future experiences with M.A.T.E.

Another setback that we encountered was an unfortunate robbery that occurred in our workshop. Although these appeared troubling times, we did not let them get us down. We banded together and provided our personal tools from home. It wasn't exactly the same as the club's resources that we were missing, but we made it work. Thankfully, we were recently contacted by campus police and notified that the suspects had been caught and arrested, and our belongings would be returned to us promptly.

Lessons Learned and Skills Gained

Members of I.D.E.A. Club always aim to learn something and we don't believe in failure. If you fail at something, it means you've done something wrong – but it doesn't mean you haven't learned anything. A wise man once said:

"I have not failed 700 times. I have not failed once. I have succeeded in proving that those 700 ways will not work. When I have eliminated the ways that will not work, I will find the way that will work." (Benjamin Franklin, c. 1847)

We have a similar outlook. Our unique circumstances required us to work together, and we learned a lot about each other. Working together became much easier once we were able to see the world from one another's point-of-view. As a group, our teamwork skills have definitely flourished, as well as our communication skills. Many of our members experienced contacting companies and organizations for the first time, requiring them to educate themselves on professionalism, a skill that will be utilized for the rest of our lives.

Future Improvements

No matter the outcome of the international competition, our team will feel successful. We know that, even though the odds were against us, we gave it our all. However, we have noted a few areas in which we would like to improve, including communication, organization, and time management. On too many occasions, we experienced more than one person dealing with a certain matter, decreasing the progress being made, and increasing a lack of supplies and available tools. In the future, we plan to assign specific tasks to individuals, as well as plan out what progress we would like to see by a certain date and apply firm deadlines. We would also like to continue to simplify our processes, with the hopes that, in future years, we will be able to edit our designs and electronics with minimal complications.

Senior Reflections

"The M.A.T.E. R.O.V. Competition has been a great experience for me. Through it, I have been able to meet some interesting and intelligent people over the years. The competition is really beneficial to get involved with. It was a learning experience beyond what you endure at school. I was able to experiment with hands-on opportunities that wouldn't be offered in a class, lecture, or lab. It was a creative outlet that allowed me to relieve my stress in a constructive manner, and has truly helped me grow as an engineer."

Stacy Correia, I.D.E.A. Club Vice President

"As a senior, I am sad that my time to participate in this competition has come to an end. These past three years have really helped me apply the knowledge that I have gained in class to real life, hands on experience. The first year I participated, I was learning what to do and I helped out a little in the building process. Last year's competition, as well as this year's competition, have really highlighted the advancement of my abilities. I have put my heart and soul into designing and building the ROV. I feel so strongly about the competition and the positive experiences it entails. It's all I ever find myself talking about anymore. Along with the incredible knowledge I have gained, my participation in the competition has gotten me an internship which led to a full time position as a mechanical engineer at Boston Power, a company that builds power cells (batteries) for electric cars. I'm so grateful to M.A.T.E. and everyone involved in the competition. I hope others have gained as much from this competition as I have."

Brandon MacDonald, I.D.E.A. Club President

Acknowledgements

Competing in the M.A.T.E. R.O.V. Competition takes a great deal of dedication. The amount of time and effort that was put into this year's competition is unimaginable. We would not be where we are today without the support of a community who believed in our dreams, and each other's abiding loyalty and commitment to the club and its endeavors.

Steven Brown

First, we would like to thank our mentor, Steven Brown. Steven is a graduate student at the University of Massachusetts – Dartmouth. He graduated in 2014 with a double-major in Computer Engineering and Electrical Engineering. Steven also happens to be the founder of I.D.E.A. Club. As the founder and a previous competitor, he understands how stressful and demanding this competition can be. Whenever we were feeling defeated, Steven was always there to give us a pat on the back and remind us to take a deep breath and find a new approach. What started as a mere advising role changed all of our lives drastically, as we gained not only a mentor but an incredible friend. He truly went above and beyond, and we can't thank him enough for his undying motivation, optimism, and support. Thanks for everything, Steve!

UMASS Dartmouth

Second, we would like to thank the University of Massachusetts – Dartmouth and its many organizations. We couldn't be more grateful for the generous donations of the Student Government Association, the Green Fee Committee, and the Engineering department. These donations have allowed us to purchase many of our supplies, as well as assist in the funding of our travel for the international competition in St. John, Newfoundland, Canada. We would also like to recognize the Dean of the College

of Engineering, Dr. Robert E. Peck, and the Assistant Dean of the College of Engineering, Dr. Ramprasad Balasubramanian, for allowing us the use of the engineering labs and tools, as well as supporting our annual interest in the M.A.T.E. R.O.V. competition. Thank you for believing in us!

Community

Last but not least, we would like to thank our community. In no specific order, the following companies have shown their support for our organization through their generous donations of supplies and services. We would like to extend our sincerest gratitude to each of you.

Appendices

Company Specification Sheet

Team: IDEA Club - *ARCTIC*
School: University of Massachusetts Dartmouth
Location: Massachusetts, United States
Travel Distance: .3 miles
Team History: UMASS Dartmouth's I.D.E.A. Club has participated in the International M.A.T.E. R.O.V. Competition three times before as members of the Explorer class. We have competed in Houston, Texas; Orlando, Florida; and Alpena, Michigan. While a few of our members are returning competitors, this will be an incredible first experiences for others.

Steven Brown – Mentor
Brandon MacDonald (President) – **Lead Mechanical Engineer** (senior)
Stacy Correia (Vice President) – **Lead Electrical Engineer** (senior)
Eddie Purtell (Treasurer) – **Chief Financial Officer** (sophomore)
Nicole Gregory (Secretary) – **Chief Executive Officer** (freshman)
Michael Benson – Electrical Engineer (freshman)
Steven Kolvek – Mechanical Engineer (freshman)
Aaron Jesus – Computer Engineer (freshman)
Joseph Hazel – Electrical Engineer (freshman)
Marc Carreira – Design Engineer (sophomore)
Adam York – Mechanical Engineer (junior)
Diarny Fernandes – Mechanical Engineer (junior)

ROV Name: ARCTIC (*A*dvanced *R*econnaissance *C*ompetitive *T*echnology *I*nvades *C*anada)

Total Cost: ~$13,000 including donations

Primary Materials Used In Construction:

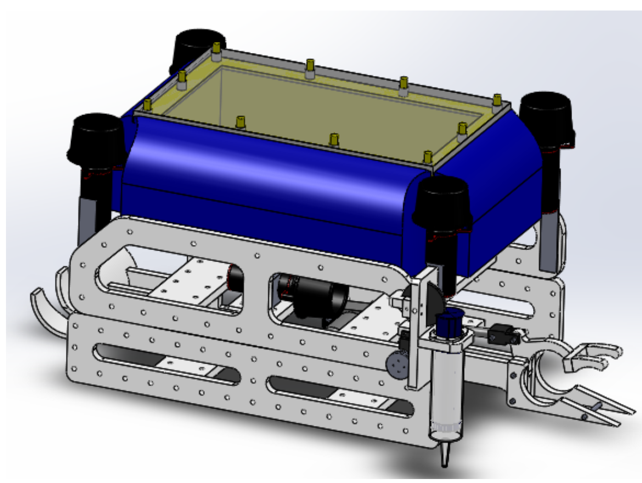
- Acrylic Tube
- Vero Black Plus 3-D Printer Plastic
- ABS
- Delryn
- Stainless Steel
- High Density Polyethylene (HDPE)

Approximate Dimensions: 64 cm x 46 cm x 41 cm

Weight: ~ 45 kg

Safety Features:

- Custom waterproof connectors to ensure tight sealed wire connections.
- Thruster shrouds
- Current, temperature, and pressure sensors in box alert pilot to problems
- Double o-ring seal
- Three layers of fuses, including the required 40A, a 30A and a 25A
    - Each one of our DC voltage regulators is redundant and cannot back-feed
- Full bridge rectifier board to avoid the disastrous error of reversed DC power polarity



Special Features:

- 4 vertical thrusters for lifting heavy loads to the surface, as well as 4 vector thrusters
- Expansion for up to 8 separate high-current tools (Speed and direction controlled)
- Compact size for tight spaces
- Ultra bright LED lights for the darkest of places.
- Multi-use front mounted claw.
- Accelerometer & compass allow precise positioning and measurements.

Systems Interconnection Diagram (SID)