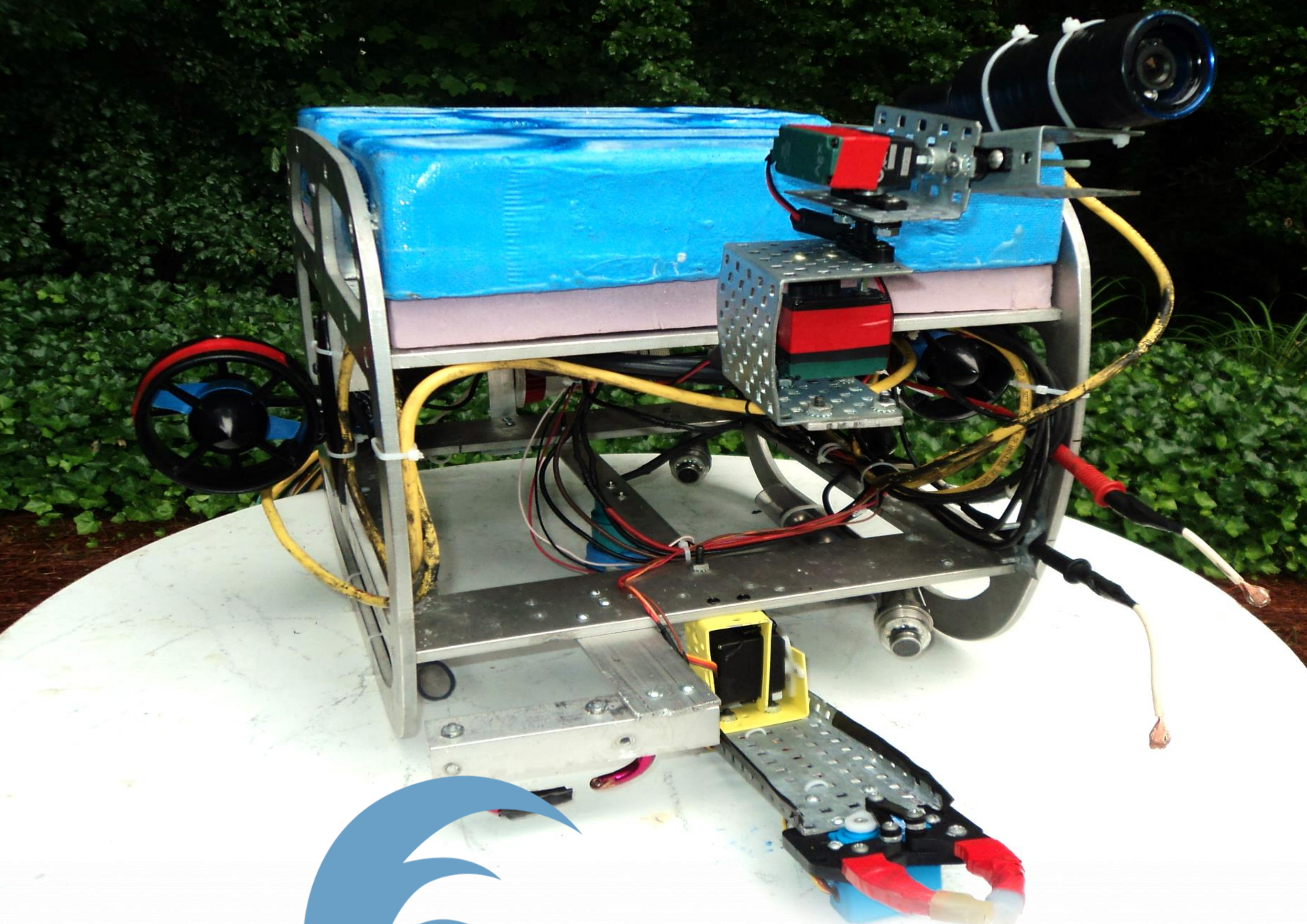


INNOVOCEAN

Innovation in Marine Technology

Carrollton High School

Carrollton, Georgia

2015 Gray's Reef Regional ROV Competition

Mentor: Kristie Bradford-Hunt

Dorothy Szymkiewicz (3rd)	CEO
Daniel Kuntz (2nd)	COO, Chief Software Engineer
Adlar Tuten (2nd)	CFO, Pilot
Robert Bennett (2nd)	Chief Executive Engineer
Connor Dempsey (3rd)	Testing & Operations
Matthew Cason (2nd)	Chief Engineer
Matthew George (2nd)	Chief Engineer
Jared Camp (2nd)	Communications
Josh Wright (2nd)	Safety Director
Jill Fazio (1st)	Government Regulations
Anthony Zheng (1st)	Head of Communications
Lacey Needham (1st)	General Engineer

Abstract

InnovOcean is an oceaneering company created in 2007 that designs, constructs, and operates Remotely Operated Vehicles (ROVs) for any mission task. In response to the Request for Proposals by the scientists of Memorial University of Newfoundland's Marine Institute (MI); National Research Council's Ocean, Coastal, and River Engineering (OCRE); and Suncor Energy, InnovOcean has designed and constructed a vehicle to study and evaluate the Canada Basin and to maintain oil pipelines. Our latest vessel, Crush, is our most advanced vehicle yet and has been designed and crafted with utmost precision and care.

Crush's services include retrieving samples from within the basin and performing repair work on oil pipelines. To perform these services, Crush features components such as an advanced digital control system, powerful thrusters, panning cameras, and a passive ballast system. Furthermore, our company has also developed seven tools specific to each service. These payloads include a measuring system, algae sampler, lift line, water pump, stationary and rotating manipulator, and conductivity sensor. Our vehicle guarantees professional analyzing of icebergs and servicing of oil pipelines.

Table of Contents


InnovOcean Employees

Company Profile

At InnovOcean, we are dedicated to not only producing efficient vehicles, but also to building both strong customer relations and company interrelations. We ensure that each member of our company is more than qualified to provide the services required by our customers. At the onset of this year, each new employee participated in a training program that was supervised and guided by experienced employees in order to learn the basics. After the program was complete, we gathered the company as a whole to brainstorm ideas for specific aspects of the ROV. Then, we split the company into smaller groups so we could specialize and optimize in these specific areas. By enforcing this strategy, CEO Dorothy Szymkiewicz and COO Lane Bye were not only able to create the most productive and skilled company possible but subsequently prepared leaders and members with a high understanding of the engineering process for future projects.

In the past, InnovOcean has varied in size and talent, and each variant required different management techniques. Last year InnovOcean was considerably larger, and the most dedicated members of our company were the senior members. As a result, they completed a majority of the work. Management problems were commonplace as many new members found themselves unable to contribute since senior members completed it themselves. This year, almost all of our senior employees have retired, leaving InnovOcean with relatively inexperienced, unseasoned, yet fresh minds. Therefore, management and organizational changes have been made to allow for better contribution, communication, and cooperation.

Moreover, since the majority of the company is relatively inexperienced, we were forced to organize and plan our company meetings in a way that would be most beneficial for newer members. There is an average of three weekly meetings with the full company, as well as other additional specific meetings. We have remained organized by setting clear deadlines for ourselves and by assigning members to appropriate groups.

Not to mention, when operating in groups, the manufacturing process is fine-tuned. For example, certain employees are able to concentrate solely on the essentials of the vehicle such as structure and propulsion, while others can focus on specific payloads. During the construction process, a separate branch contains members devoted to research, development, and marketing. Each group affects other aspects of the vehicle, allowing team members to garner an understanding of all parts of the company.

Safety

Safety is a top priority for InnovOcean. While constructing Crush, all employees practiced safe habits such as wearing eye protection, wearing closed toed shoes, not wearing baggy clothing, tying back long hair, and wearing gloves or ear plugs when necessary. Additionally, InnovOcean operates in a safe, organized environment. We clean our workshop after every meeting in order to ensure a consistently orderly workspace. By keeping our workshop organized, we decrease the number of potential safety hazards. Our workshop includes a tool wall for keeping equipment neat and contained, as well as various stations for different tasks. Our build station is set-up with power tools, safety gear, clamps, vices, etc., while the electrical station houses all wiring tools and provides an out-of-the-way area for soldering. Our workshop also houses a grinding station. A potential injury of severely scraped hands and injured eyes was avoided at our grinding station when a member was, fortunately, wearing eye protection and work gloves.

InnovOcean employee practicing safety procedures

Moreover, InnovOcean's dedication to safety is evident in the numerous safety features on Crush. Crush incorporates an array of safety precautions, including a 25 amp fuse to protect the onboard electronic components. Furthermore, all thruster and camera cords are pulled taut around the frame to minimize slack and prevent entanglement with any moving parts. All thrusters are equipped with safety partitions, and the tether is covered in an abrasion resistant wrap. In addition, Crush's frame design allows for all moving parts to be confined within the frame. Our control box, a water-tight Pelican case, also features safety stickers to warn employees of potential hazards and a LEXAN sheeting cover to further prevent harm. Furthermore, the company follows a strict checklist before putting the ROV in the pool and during take down (See Appendix A). These protocols are enforced in order to protect and guarantee safety for all members from moving parts and "hot" wires.

Brief Safety Checklist

Apparatus Protection

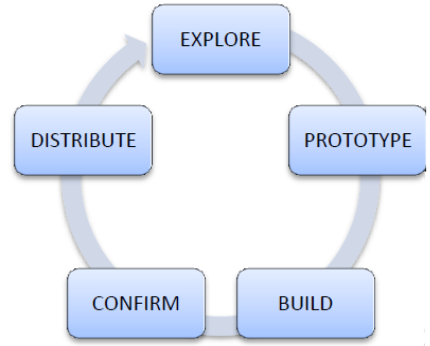
- Are you experienced with the machine operations?
- Has the machine been inspected for damage?

Personal Protection

- Safety glasses
- Closed toed shoes
- Long hair tied back
- Gloves (if necessary)
- Ear plugs (if necessary)
- No jewelry or baggy clothes

The Design Cycle

An important goal of InnovOcean is to follow a specific design process throughout vehicle construction and creation of marketing techniques. We have striven to ensure that every component of Crush has been designed and tested to perfection. To accomplish this, we developed a design cycle that outlines all steps in the creation of our components. At InnovOcean, we begin by brainstorming ideas for each task or component of the ROV. After evaluating each design, we narrow down the list by asking ourselves the following questions:

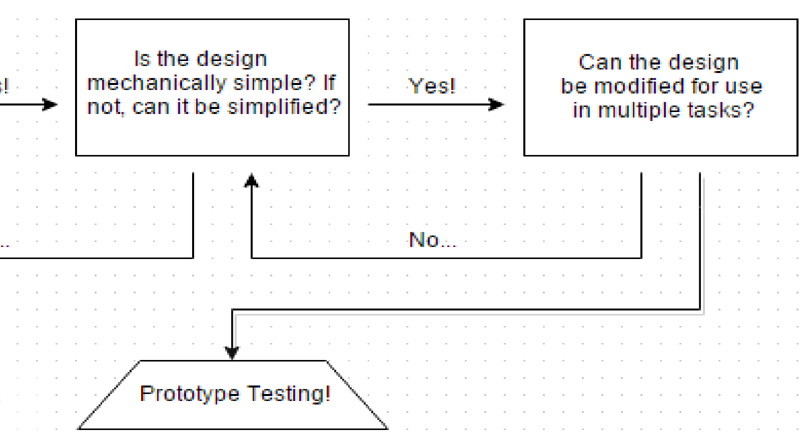


Design Cycle

1. Is the design feasible and realistic?
2. Is the design mechanically simple? If not, can it be simplified?
3. Can the design be modified for use in multiple tasks?

If either the first or second questions were answered "no," we would scrap the design. If each question was answered "yes," we would continue to modify each as necessary. After testing a prototype successfully, a final product would be built and tested. If we found this prototype to be effective, we would implement the component in the final ROV for distribution to customers. When InnovOcean employees began brainstorming the line of vehicles to service MI, OCRE, and Suncor Energy, we created a set list of focal points that would permit the vehicles to operate at optimal efficiency:

- Decreasing mass while increasing speed and maneuverability
- Using simple, yet effective payloads to complete all services
- Maintaining a sleek design for appeal to customers
- Conserving materials and resources whenever possible
- Practicing performance safety



Prototype Design Cycle

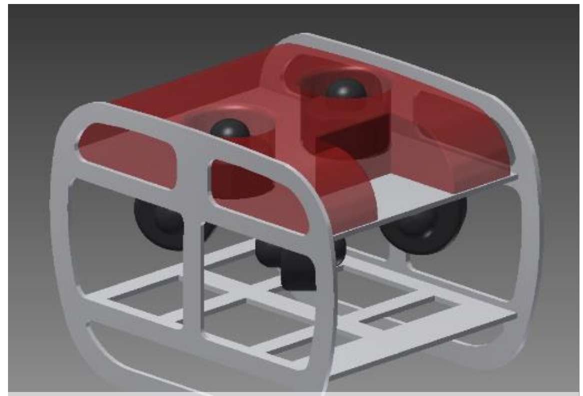
Design Rationale

InnovOcean's newest vehicle, Crush, performs exceptional services using six basic systems: Frame, Ballast, Propulsion, Cameras, Controls, and Payloads.

Frame

Throughout our history, InnovOcean has either developed specialty frames for each of our vehicles or has recycled a previous years' frame. Last year due to money and time restraints, our team decided to use a recycled frame from a previous model. However, we realized that doing so limits our abilities to optimize the performance of our ROV for each year's unique tasks. This year, we began our design process by researching the frames of professional ROVs. Our research results concluded that most working-class ROVs have a very open, rectangular-prism-like frame, so we decided that the best frame for our purposes would be one similar those we studied.

Crush's frame is composed of 0.635 cm thick 20-24 grade aluminum creating a sturdy yet lightweight structure. We designed each prototype in AutoDesk's AutoCAD and Inventor. Afterwards, we created multiple wooden models to allow us to examine and decide the appropriate size and shape of the frame. Measuring 44.7 cm long, 54.0 cm wide and 33.5 cm tall, the final frame was professionally cut using a high-pressure water jet machine by Advanced Precision Manufacturing, Incorporated. Sides of the frame are tapered to allow Crush to move faster and be more hydrodynamic.


AutoCAD Inventor Frame Design


Wooden Frame Prototype


Manufactured Aluminum Frame

Ballast

In the past, our vehicles have featured multiple asymmetrical ballast tanks or ballast cubes. We thought that this set up would provide us with the ease to adjust to neutral buoyancy. However, after last year's failed attempt, we decided that we could streamline production and the ROV by creating one main ballast tank. This tank was cut out of a sheet of 2" Schlüter-KERDI-BOARD. To elaborate, this foam board is a multifunctional tile substrate and building panel, and can be used for creating bonded waterproofing assemblies with tile coverings. It consists of an extruded polystyrene foam panel, with a special reinforcement material on both sides and fleece webbing. The foam is closed cell, meaning that all air pockets inside the foam are separate.

Ballast curing after applying epoxy

Completed Ballast

Furthermore, to properly seal the tank, we covered the foam with fiberglass cloth and sealed it with marine fiberglass epoxy resin. After allowing time to dry, we sanded and painted the ballast with marine paint. Even if water should penetrate the seal and fill an air pocket, it will not spread to any others, allowing the ROV to remain neutrally buoyant. After testing the ROV in water with the main ballast, Crush was found to be slightly negatively buoyant, so we added purple insulation foam to make minute adjustments to achieve neutral buoyancy.

Propulsion

Lateral thruster

Another major focus in this year's vehicle design was maneuverability, and this was given much consideration when determining thruster orientation. In previous years we have used Seabotix thrusters, however after many years of use, their lives has ended. After considering buying from Seabotix again, we found a new company called Blue Robotics that offered similar thrusters for project use. We bought six T100 thrusters paired with

BlueESC speed controllers. Not only were these thrusters much cheaper, they were also lighter, smaller, and more powerful.

Crush features a total of four thrusters, two for lateral motion and two for vertical motion. The lateral thrusters are mounted in the middle of the outer edge of the frame, while the vertical thrusters are mounted within the frame on aluminum c-channels. Each thruster draws 4 amps of power and provides up to 23.1 N of thrust. All T100 thrusters feature safety partitions around the propellers to protect both InnovOcean employees and marine life.


Vertical and lateral thrusters

Cameras

Crush houses four marine cameras from Lights Camera Action: two Blu-Vue 700 cameras and two AquaCam cameras. Our design team quickly realized that in servicing oil pipelines, having extra camera views would be extremely valuable. In the past, we have successfully developed a rotating and panning camera, and has proven to be imperative for the success of our vehicle. Therefore, we prioritized its development.


AquaCam Camera

We began brainstorming and drew detailed sketches of each idea. We designed several unique systems – one consisting of a camera on a track around the circumference of the frame, another with multiple cameras each with their own individual movement. After considering these designs, we chose to pursue prototyping a system consisting of one panning and rotating camera. The system consists of a short single axle connected via gearbox to a servo motor for our main camera, one of the Blu-Vue 700s. In addition, the other Blu-Vue 700 and AquaCam cameras are mounted on the ROV to provide alternate views of our payloads. Our cameras also feature 6 white Light Emitting Diode (LED) lights for vision underneath icebergs and on the ocean floor.


Blu-Vue 700 Rotating/Panning Camera Mount

Control System

Our current model of Crush houses InnovOcean's most advanced control system to date. In the past, we have employed various hardware-based systems that involved little to no software in their design. Such systems were comprised primarily of toggle switches that only allowed for the on or off control of our thrusters. As our ROV technology developed, we recognized the need to develop our controls as well. Eventually, we expanded our controls to encompass an Xbox controller, Arduino, and complex computer program. This year, we have advanced the design of our control system while focusing on two priorities: portability and tidiness.


Control Box

Transmitter

This year, we have stepped away from using the Arduino as the basis of thruster controls in favor of using an RC receiver and transmitter. When we give input on our transmitter, the signals are wirelessly sent to our receiver, which then sends the appropriate signals to each motor on the ROV. Our new RC transmitter is superior to the PlayStation or Xbox controllers we have used in years past for three main reasons. Firstly, it is fully programmable without the need for an Arduino or computer: all programming takes place on the transmitter itself. Secondly, our transmitter features a multitude of switches that are fully programmable. Thirdly, our transmitter features control sticks that are much larger and considerably smoother than that of a PlayStation or Xbox controller, allowing for more precise control.

When we purchased the new thrusters, we also purchased new motor controllers: Electronic Speed Controllers (ESCs). Unlike our previous motor controllers, these ESCs are much smaller. Each ESC has a total of eight leads, three connecting through the tether to each motor on the ROV, two power, and three connecting to the receiver. The positive and negative leads are connected to a central plate that routes all positive and negative leads to one central positive and negative input, which is connected to the power supply through a heavy duty EC5 connector. The remaining leads plug into our receiver unit which is on board the ROV.

Waterproofed ESCs

Four thrusters and one payload motor (of the rotating manipulator) are powered by five ESCs. Originally, we had set up our control system so that the ESCs and receiver were on the surface inside the control box. However, we realized after testing that the voltage drop over the entire length of tether was too much – there wasn't enough power going to the ESCs or thrusters. After several attempts at waterproofing the ESCs in a watertight box failed due to overheating, we successfully waterproofed them by simply coating them in epoxy. Each ESC has six MOSFETs, or integrated circuits, which produce heat. To transfer this heat to the water, we covered the MOSFETs with heat transfer paste, which is used in computer parts, and epoxied the side of the ESC with the MOSFETs to an aluminum c-channel. This c-channel was then mounted to Crush's frame. This set up allows the heat to transfer from the ESC to the aluminum and dissipate through the water.

We also mounted and epoxied the RC receiver on board the ROV. This configuration decreased the diameter and mass of our entire tether because it eliminated the need to extend all the signal wires of each ESC, totaling 15 leads, through the tether to the control box. The RC receiver sends signals to the transmitter through leads that connect to satellite receivers, which are located in our control box.

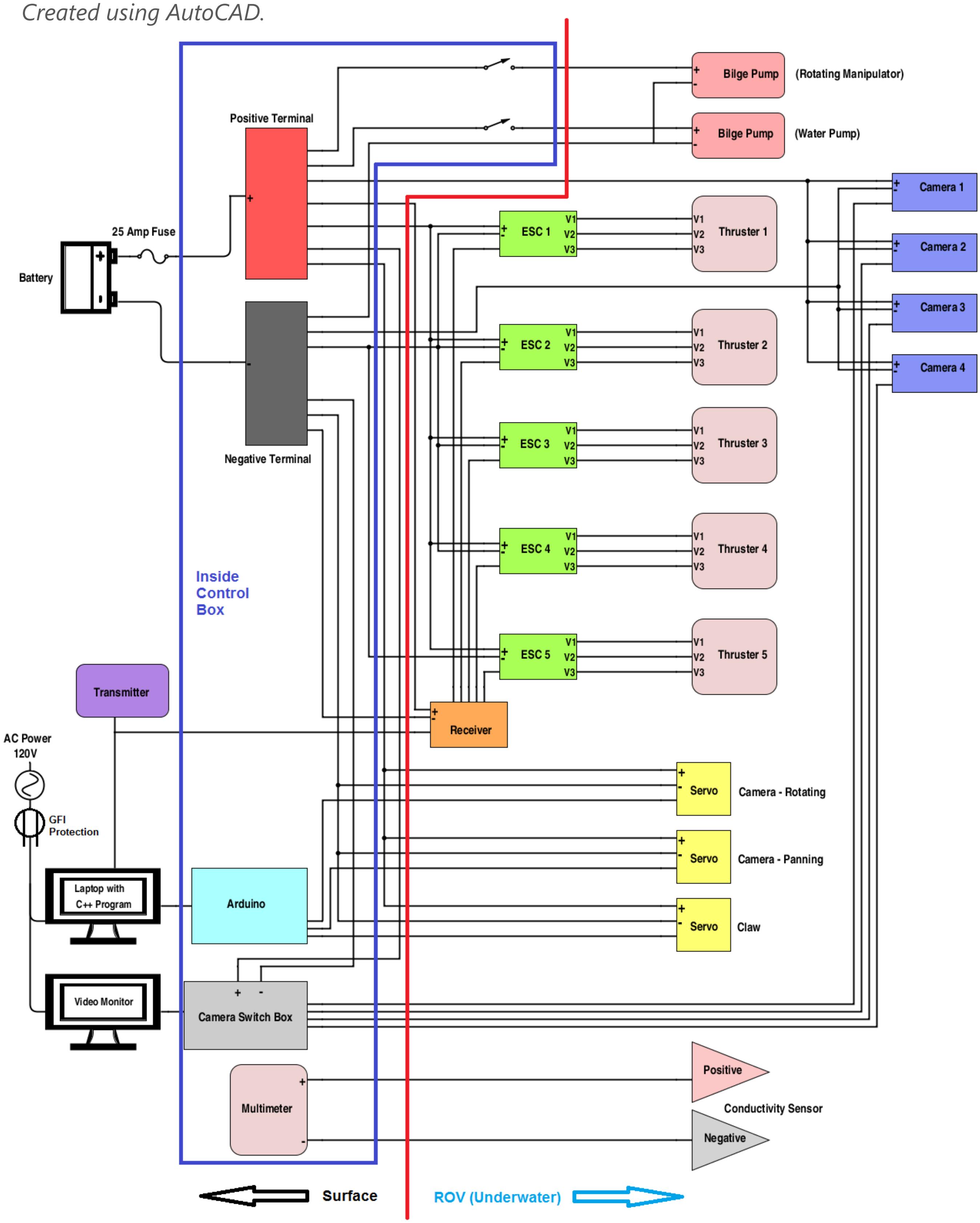
Epoxied RC receiver

In order to keep all circuitry untangled and protected, we drilled holes into a piece of wood and zip-tied all of the main components, switches, and battery and tether connectors down. We found this to be the best solution because components can easily be moved, added, or removed if necessary, and it maintains a sleek design. Our entire arrangement is sealed in a watertight Pelican case that features a point-of-no-tension that connects the tether to the control box through two 20-pin connectors.

Crush's tether includes 15 leads, seven 18-gauge and eight 12-gauge wire, and four camera cables bundled in an abrasion-resistant tether wrap. To counteract the negative buoyancy of the tether, we attached many Styrofoam balls of 4 cm diameter to the tether to achieve neutral buoyancy. In the past, we attempted to use grey insulation tubing for tether buoyancy. However, we realized that the material was open-cell, causing water to flood and soak the foam. The Styrofoam balls, on the other hand, have proven to be very effective.

SID

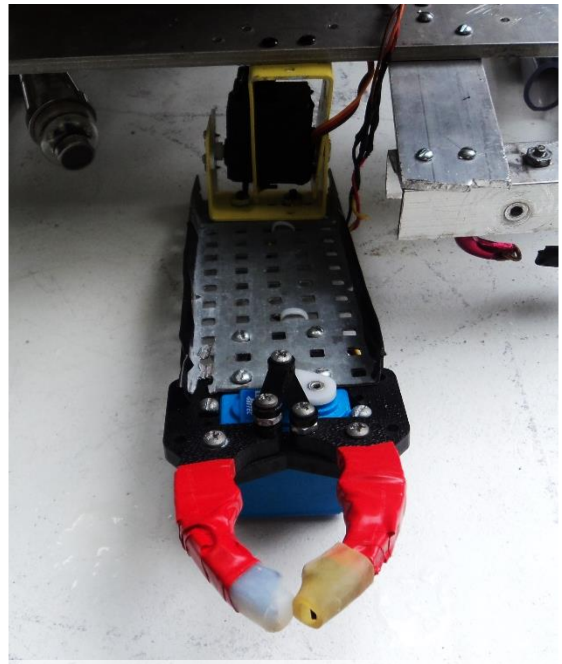
Created using AutoCAD.



Payloads

Manipulator

Arguably the most important ability of any ROV especially in oil pipeline maintenance and is the manipulation of the pipeline and the environment. We realized that for certain task, such as manipulating the bolts and picking up the sea urchin, a manipulator was a necessity. Due to time restraints, we purchased a manipulator from SparkFun Electronics. Measuring 12.7 cm long by 7.6 cm wide, the manipulator has an opening width of 12.7 cm. A waterproof servo (HS-646WP) from Hitec provides movement to the manipulator. Furthermore, we fabricated a mount that provides up and down movement to the manipulator using modified aluminum brackets powered by a high-strength water-proof servo. This allows for the more efficient manipulation of objects in missions.



Manipulator

Algae Sampler

Out of inspiration from a tennis ball collector, we created an algae sampler that would effectively remove samples of algae from underneath the ice sheet. It is made out of rubber bands and modified aluminum bars and measures 32.4 cm long, 25.4 cm wide, and 14.6 cm tall. We mounted the sampler to the top of the ROV to allow for simple maneuvering by pressing up against the ice sheet. Since the rubber bands are evenly spaced at intervals smaller than the diameter of the balls, the ping pong balls can easily slide into the container and remain inside. We have also designed the sampler to be easily removable, for the optimization of space during other missions.

Algae Sampler

Measuring System

Each mission requires us to measure the length of a particular item, whether it be a section of corroded pipeline or a wellhead. After considering the use of a physical tape measure, our company chose to use a software approach. We decided to implement a simple scale, a 40 cm "XYZ" axis made of Polyvinyl Chloride (PVC) piping. On our initial decent of each mission, the ROV will place the PVC scale flush with any item that requires measuring. By splicing our camera feed we are able to view the mission on the monitor and simultaneously on a laptop. It then becomes a quick task of taking screenshots of the item and scale from the laptop. Once the screenshots have been gathered, the co-pilot will transfer them into AutoCAD where the item's dimensions will be based off the scale. This method is extremely time efficient and gives accurate measurements each time.

XYZ axis

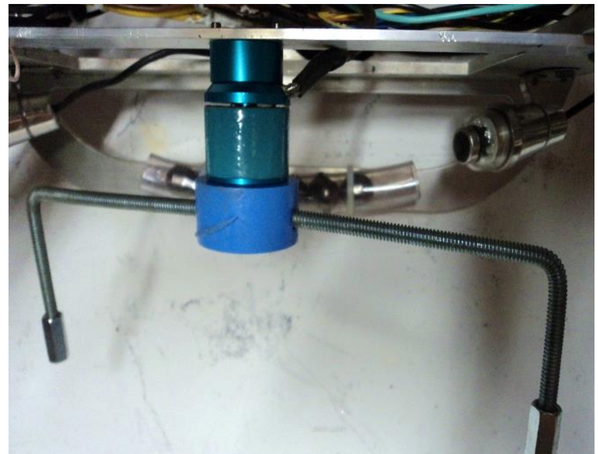
Conductivity Sensor

Conductivity Sensor

To test the grounding of anodes, we have implemented a modified multimeter into our system. We have extended the leads from the meter from the surface through the tether to prongs mounted on the ROV. The distance between these prongs is the same as the distance between two grounding anodes on the oil platform. Furthermore, we soldered wire on each prong and attached strong magnets to the end of each wire. By doing this, we decrease the need of precision piloting in connecting the two prongs to their exact anodes and guarantee a secure connection for proper measurements. Using the multimeter, we can measure the voltage in volts Using the multimeter, we can measure the voltage in volts (V). If voltage is evident, then we know we have identified a leg of an oil platform that is subject to galvanic corrosion.

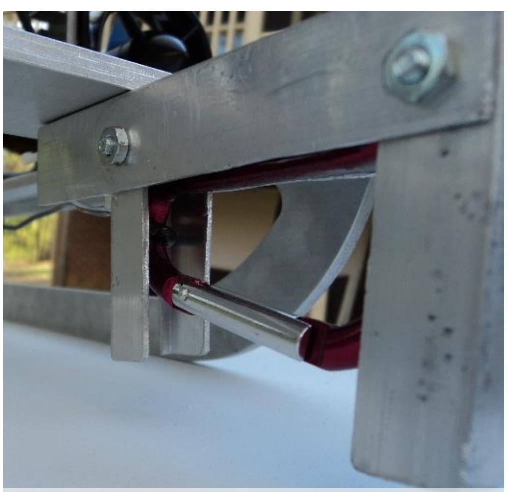
Rotating Manipulator

The missions include the tasks of turning various valves remotely. Several prototypes were originally drafted; the most popular and plausible of these included attaching a pair of rods to the bottom of the ROV and using the thrusters to turn the ROV into a lever. The main issue with this design was that it required a near-zero turn radius, which was something we could not rely on. For our regional competition, our company constructed a device utilizing gears, VEX components, and a bilge pump. Through a gear mechanism, the bilge pump would turn a fork of metal rods that would open and close the valves. This design, however, was fairly unstable, unsound, and unreliable. After continued research and consideration, we decided to use a simple waterproof, brushless motor from Blue Robotics. Attached to the motor is a pair of modified threaded, steel rod. These prongs are removable via coupling nut. This new improved design proved to be sturdier, simpler, and more reliable – following InnovOcean's design guidelines.



Rotating Manipulator

Lift Line



Carabiner of Lift Line

In order to remove corroded sections of pipeline, we have created a lift line that can be used quickly and effectively. While brainstorming, we realized that the simple mechanics of a magnet and a carabiner were exactly what we needed to effectively complete this task. The ROV will lower onto the U-bolt of the pipeline to attach the carabiner, with an aluminum c-channel housing to keep the carabineer in place. Within the aluminum housing, we have mounted a magnet with aluminum mesh. While holding the magnet in place, the mesh does not break the magnetic attraction between the carabiner and the magnet - thus providing a strong

Plastic Hook and Wire

enough bond to keep the carabiner attached and to allow the carabiner to detach when needed. Once the carabiner is secure, the ROV will pull away from the pipeline, detaching the lift line from the magnet. Since there was no guarantee that nylon rope could remain clear of thrusters, we decided to attach a section of wire to the carabiner that was stiff enough to remain in place with the help of a flexible plastic hook. Continuing a couple feet down the line, the wire transitions to nylon rope which the deck team will use to pull up the sections of corroded pipeline.

Water Pump

Testing the oil pipeline system requires the use of a water source provided by our company. We decided to use a bilge pump as it is a simple, yet dependable source of water flow. The bilge pump is mounted on the back of Crush. The pilot utilizes our reverse navigating software to line the bilge pump with the opening of the pipeline. Once the ROV is in line, we engage the bilge pump, pushing water through the pipeline. This process allows us to properly test the oil pipeline and ensure that oil will exit through the appropriate outlet.

Water Pump

Budget and Project Costing

Building an ROV is no simple task, it requires planning and considerable cooperation. In order to have accomplished such a successful vehicle this year, we had to lay out a budget for purchased elements. Initially, our company had budgeted $2,300.00 to construct the ROV and at the end we did well, coming roughly $500 under budget (See Appendix B and C). Some of the items on Crush were graciously donated from different sources, while a number of others were built out of purchased materials. A few select parts were also re-used from previous years.

Challenges

Throughout the duration of this project, InnovOcean experienced various challenges that we had to overcome. We encountered both technical and company based obstacles, and sometimes these tasks became overwhelming. However, company members worked together to transcend these challenges and find innovative solutions to solve all technical and company based problems.

Time Management – Non-Technical Challenge

This year time management became a severe issue. We faced multitudes of challenges involving deadlines and team activeness. We decided to plan a strict yet reasonable schedule for meetings and deadlines, and it was effective in the short-run but faced issues in the long-run. Each and every one of our members are qualified and talented in many different aspects such as academics, athletics, and arts. Their commitment to other extracurricular activities caused activeness issues among some of the members.

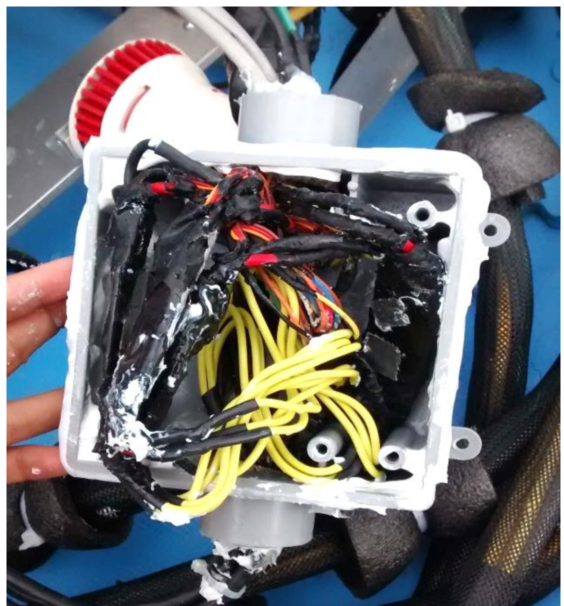
Furthermore, we came across challenges in deadlines especially with the frame. Due to the ideal of having the most optimized model for our customers, we experimented and cut wooden models of any frame that might have appropriate for the tasks. When considering how much each time it took for modeling a frame in AutoCAD, cutting out a wooden model for experimentation, and eventually settling on a design, we had to push back our initial deadline for the frame's completion.

Other time-related issues came with the loss of our experienced team members. Since most of the accumulated knowledge of ROV specifics had left with the last graduating class, we were at times unequipped with the necessary information needed to complete certain parts of the vehicle. For example, when wiring the camera cables to a signal cord, we assumed that they were to be wired in a certain way. However after wiring, we realized that we had completed the task incorrectly. We spent an entire day deliberating and laboring over what was the correct wiring setup. After a mistaken connection, we discovered the correct wiring setup. With the knowledge of last year's seniors we would have been able to complete what took a day's time in an hour. Though overwhelmed with such issues, we were still able to complete the ROV on time. Our members dedicated every spare hour in their busy schedules to ROV.

Waterproofing ESCs – Technical Challenge

One of the most devastating events of this past year was when all our ESCs had completely fried, a week before the regional competition, due to failed waterproofing. Our original waterproofing design involved inserting liquid-taped and electrical-taped ESCs into a small plastic junction box. The box was then sealed with epoxy and polyurethane caulk. A sheet of clear plexiglass was used as the cover so employees could easily check for water leakage – this plexiglass was sealed along the edges with the caulk and was securely fastened with plastic blocks and hose clamps. The design was completely foolproof, considering the ESCs would not overheat.

After fifteen minutes of smoothly running the ROV in the water, all controls through the ESCs had stopped. Much to our surprise, the ESCs had become so hot that the heat melted through the thick layer of epoxy and polyurethane – thus, flooding the entire box and frying the ESCs. We were devastated. Quickly, we ordered a new set of ESCs while we considered our next approach. We decided that it would be best to epoxy them with heat transfer paste to an aluminum bar. This design would provide for better heat transfer, for the heat would transfer from the MOSFETs on the ESCs to the aluminum to the water.



Destroyed Waterproof Box for ESCs

With three days to spare, we received the new ESCs in the mail. With two days to spare, we tested the ROV once again with the new waterproofing method. Success. The new method was excellent. We had no further issues and could continue practicing to prepare for regionals. Despite these challenges, our company was able to perform successfully and proceed to the international competition.

Lessons Learned

As InnovOcean is a fairly new marine machining company, we recognize that there are many lessons to be learned in terms of being a successful business. Fortunately, we are learning these lessons with each ROV we build. There are, of course, lessons we have learned which are specific to Crush and the 2014-2015 staff of InnovOcean.

Interpersonal Lessons Learned

The past couple years have been building years for InnovOcean. Several top company members graduated in 2014, leaving behind few experienced members. Fortunately, this year we recruited several new members – each have been extremely eager to build an efficient vehicle. Eagerness without skill, however, is unproductive and wasteful. Since there will be more seniors graduating in the next two years, we found it imperative to ensure that the younger members of the team are prepared to run the team. In this preparation, our chief pilot decided to step down and let the newer members, Adlar Tuten and Daniel Kuntz, to pilot the vehicle. Due to InnovOcean's efforts in training, every member of our team is fully qualified to pilot Crush and explain our product to potential customers.

Furthermore, since InnovOcean is a student run organization, we have grown fairly independent. We were under the impression that we could fix and design everything ourselves with no problems – we conducted ourselves in a way without much outside advice. Later in the season, we realized the need for guidance. When we received it, we found ourselves operating in a much more efficient manner. In the future, InnovOcean will take a much more open approach to asking for advice.

Technical Lessons Learned

Another important lesson our team learned this year was the idea that we innovate and design components on Crush ourselves and limit the amount of commercialized components we purchase. Not only were we able to build mechanical items, we also gained experience in building our own electronics, specifically circuit boards. Team members who had never soldered before were able to construct functioning circuits within a few weeks. Through this process, InnovOcean has become much more effective at designing and innovating Crush and future ROV's for any mission tasks.

Future Improvements

InnovOcean is constantly looking for ways to advance. There is always room for improvement whether it be in the design, function, and controls of the vehicle or even in the structure of the research branch of our company. This year we feel that the following three improvements would have benefited us tremendously.

The first improvement has to do with our company's mindset. Throughout our company's history, we have consistently finished tasks with a "just-get-it-done" attitude. This year especially, we have realized that not committing fully to a task the first try causes serious setbacks later with failing parts and contracting time. Next year, we plan to do more research, prepare more thoroughly, and ask for more advice before conducting any trials. Taking more time to plan in the beginning, will save much more time later. This improvement in mindset will allow for a more efficient organization.

Secondly, we plan to improve the core of our ROV's design: the frame. Streamlining the frame's design will benefit the vehicle tremendously. Throughout our past, we have been comfortable using a heavy metal or plastic to construct our frame. Next year, we plan to examine other materials for our frame, such as carbon fiber: a much lighter, yet very sturdy material. This change will decrease the overall mass of our ROV, allowing us to further manipulate the centers of gravity and buoyancy – leading to a sturdier, sleeker, and more balanced design. In sum, both these improvements will allow for a better and more efficient ROV and oceaneering company.

InnovOcean Employees and Future Recruits (from CMS and CJHS)

Reflections

At the onset of the year, it was very clear that as a team, while we were all united through one common goal, we were divided into three separate groups: seniors, returning members, and new members. In a way, this was actually very beneficial for us because it provided three different perspectives that we would not have had otherwise. With that said, we also thought that in reflecting on this year's experience, it was important to take into account these three insights, so we asked each group to collectively craft a statement to represent their experience with InnovOcean this year.

New Member

"During my first year with InnovOcean, I have learned so much about engineering and life skills that I thought I would never learn until later. I really enjoy being a member of the team because I was pushed beyond my comfort zone and was encouraged to try many new things. I hope to continue to learn and grow in my future years as a member of InnovOcean, and I am excited to see where this organization will go."

~ Jill Fazio, Government Regulations

Returning Member

"As a returning member to InnovOcean, I can say that this experience continues to amaze me. I continue to learn more about the people on the team as well as engineering and ROVs. Freshman year, I was simply an engineer for InnovOcean. This year I have been entitled as the CFO and pilot of the company, which has been an honor and challenge. Even in one year, I have seen growth in the company and hope that it continues. I look forward to my remaining years as a member of the team."

~ Adlar Tuten, CFO, Pilot

Senior Member

"This year has been a critical year for me because most of our experienced team members graduated, which resulted in other less experienced members and me having to step up and take responsibility for the team's success. ROV is extremely important to me because it has given me an opportunity to put my knowledge towards constructing a much more complex machine than I could myself. Doing so with other people who share the same passion for technology as I do is incredible."

~ Daniel Kuntz, COO, Chief Software Engineer

Acknowledgements

InnovOcean would like to recognize several sponsors and individuals for their support and help throughout this year. Carrollton High School has allowed us to use the STEM equipment to help add special features, like rotation to our cameras. We give sincere appreciation for Mr. Art Powers at Advanced Precision Manufacturing, Incorporated for his aid in cutting out our frame. InnovOcean would also like to thank Mr. D, Mr. Melton, Mr. Dempsey, and Time Warner Cable for their generous donations to our team. We would like to thank Mr. Matt Greene, who willingly devoted some of his time to aid us in designing the logo by introducing us to new software. We appreciate the support of Sunset Hills Country Club for permitting us to utilize their pool for practice. We would also like to thank Ozier Apparel for providing us with custom-embroidered polos. Additionally, we would like to give a special thanks to our parents and families for their advice, inspiration, and encouragement as we take on new challenging endeavors. Two individuals, in particular, have gone out of their way to make this year possible; Papa Sam and Mrs. Ann Price have offered the team a meeting space where we can collaborate and use their workshop for construction. Without the support of our mentor, Kristi Bradford-Hunt, none of our accomplishments would have been possible. She has ensured that we stay organized, has guided us along the way, and has never stopped believing in us. We appreciate all that these individuals and organizations have done! Finally, InnovOcean would like to acknowledge Gray's Reef National Marine Sanctuary and MATE for giving us the opportunity to participate in such an amazing experience.

Servicing Warranty

To ensure customer satisfaction and reflect InnovOcean's confidence in our product, Crush, a one year servicing warranty is included with each vehicle. If at any time a system fails due to a technical malfunction, an InnovOcean engineer will fix and/or replace that part or system at no expense to the customer.

Appendices

Appendix A – Safety Checklist

PRE-MISSION LIST

Physical

- All items attached to ROV are secure and will not fall off (Check connections)
- Hazardous items are identified and protection provided.
- Propellers are enclosed inside the frame of the ROV or shrouded such that they will not make contact with items outside of the ROV (Check Safety Partitions)
- No sharp edges or elements of ROV design that could cause injury to personnel or damage to pool surface

Electrical

- Standard male Banana plugs to connect to MATE power source.
- 25 amp Single Inline fuse or circuit breaker within 30cm of attachment point (Check Fuse)
- No exposed copper or bare wire (Check connections, use electrical tape or liquid tape if required)
- No exposed motors
- All wiring securely fastened and properly sealed (check connections, especially at control box and at conduit)
- Tether is properly secured at surface control point and at ROV
- Any splices in tether are properly sealed
- Surface controls: All wiring and devices properly secured
- Surface controls: All control elements are mounted with wiring inside an enclosure.

DECK COMMAND LIST

"Going Hot"- This is the pilot's signal to all deck members that the ROV is about to be powered on.

"All Hands Clear" - Everyone should remove hands and other extremities from the ROV and its moving components.

"We're Cold" – This is the pilot's signal to all deck members that the ROV has been disconnected from the battery and is okay to handle.

"Tether" – This tells the tether manager to feed more tether into the pool.

Appendix B – Budget

Category	Amount to Spend
Payloads	$ 300.00
Frame	$ 75.00
Tether	$ 200.00
Control	$ 250.00
Propulsion	$ 700.00
Supplies/Props	$ 600.00
Buoyancy	$ 50.00
Total	**$ 2,300.00**

Appendix C – Project Costing

Deposits				
Description	**Type**	**Vendor**	**Amount**	**Balance**
2013-2014 ROV Balance	Remaining Funds	ROV Account	$ 2,100.00	$ 2,100.00
Mr. Melton & Mr. D	Donation	Previous Teachers	$ 500.00	$ 2,600.00
Poinsetta Fundraiser	Fundraiser	Georgia Greenhouses	$ 726.00	$ 3,326.00
ROV Dues	Dues	ROV Members	$ 2,000.00	$ 5,326.00

Expenditures				
Description	**Source**	**Vendor**	**Value**	**Balance**
Supplies/Props				
Props	Purchased	Home Depot	$ 504.87	$ 4,821.13
Electrical/Liquid Tape	Purchased	Home Depot	$ 14.67	$ 4,806.46
Regular Epoxy	Purchased	Home Depot	$ 16.45	$ 4,790.01
Misc.	Purchased	Home Depot	$ 68.21	$ 4,721.80
Frame				
Frame	Donated	Art Powers at APM, Inc.	$ 112.32	$ 4,721.80
Propulsion				
Thrusters	Purchased	Blue Robotics	$ 804.00	$ 3,917.80
Ballast				
Fiberglass Epoxy Resin	Purchased	AutoZone	$ 22.45	$ 3,895.35
Fiberglass Cloth	Purchased	AutoZone	$ 6.07	$ 3,889.28
Paint	Purchased	Home Depot	$ 2.78	$ 3,886.50
Shlüter Board	Donated	Paul Szymkiewicz	$ 15.00	$ 3,886.50
Tether				
Cable	Purchased	Security Solutions	$ 176.43	$ 3,710.07
Abrasion-Resistant Wrap	Re-Used	N/A	$ 54.79	$ 3,710.07
Control				
Connectors	Purchased	WayTek, Inc.	$ 30.13	$ 3,679.94
Recievers	Purchased	Amazon.com	$ 25.96	$ 3,653.98
Transmitter	Donated	Daniel Kuntz (team member)	$ 90.00	$ 3,653.98
Box	Re-Used	Pelican	$ 69.95	$ 3,653.98
Cameras				
Cameras	Re-Used	Lights, Camera, Action	$ 6,190.00	$ 3,653.98
Payload Materials				
Aluminum Claw and Servo	Purchased	SparkFun	$ 16.54	$ 3,637.44
Plastic Claw and Servo	Purchased	SparkFun	$ 57.49	$ 3,579.95

Aluminum pieces	Purchased	Home Depot	$ 50.56	$ 3,529.39
Lift Line	Purchased	Home Depot	$ 5.55	$ 3,523.84
Pecan Picker	Purchased	Home Depot	$ 4.60	$ 3,519.24
Masumune	Re-Used/Donated	Carrollton High School STEM	$ 42.30	$ 3,519.24
Bilge Pump	Re-Used	Walmart	$ 24.19	$ 3,519.24
Measuring System	Re-Used	Home Depot	$ 8.15	$ 3,519.24
Apparel				
Polo Shirts	Donated	Ozier Apparel	$ 396.00	$ 3,519.24
TOTAL			**$ 8,809.46**	**$ 3,519.24**
Total Value of ROV		**$ 7908.54**		
Total Amount Spent This Year Only on the ROV		**$ 1301.89**		
Total Amount Spent This Year		**$ 1806.76**		