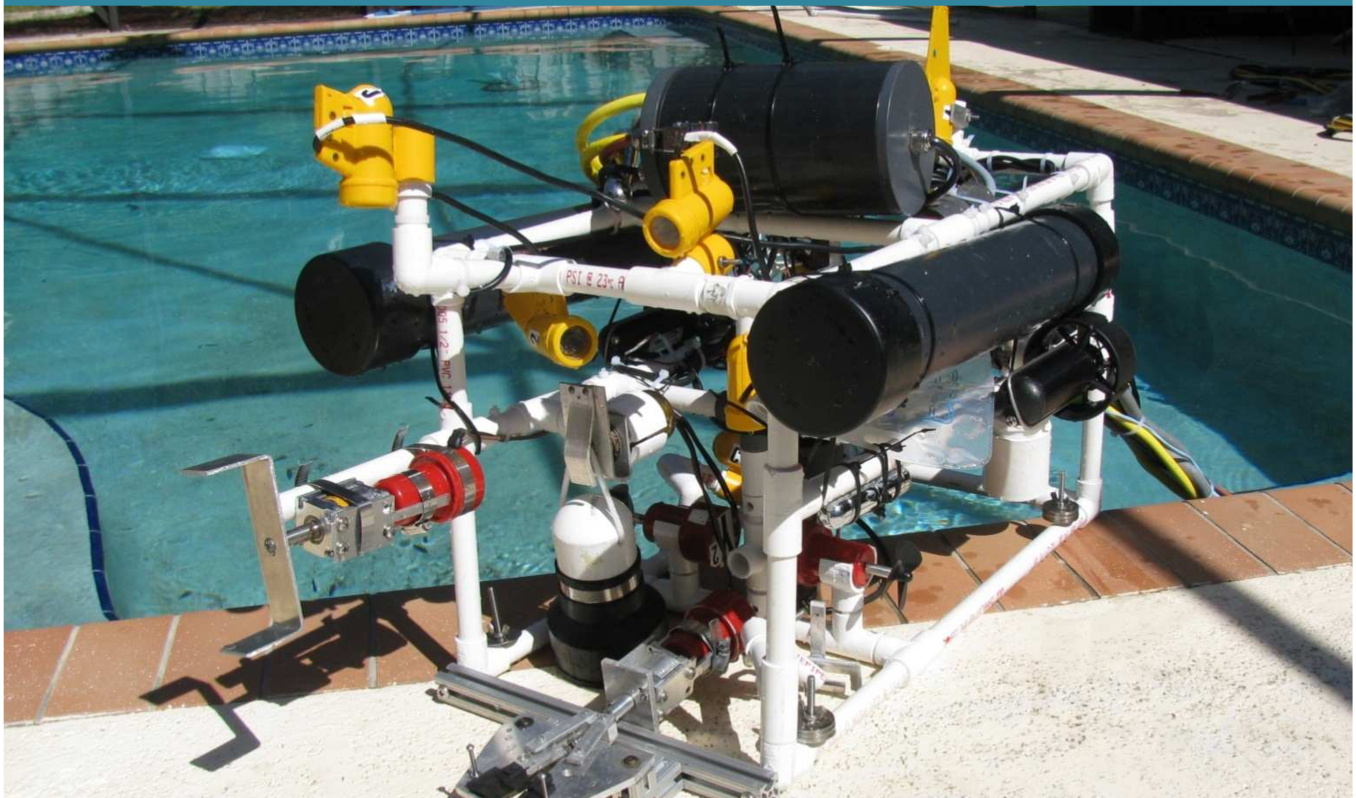
DeepView Technologies    Gainesville Florida



# Cornerstone Robotics Technical Report

Photo of the completed ROV “Clean Break”

(left to right: Spencer, Sheppard, Angerhofer, Sorrels, Hurlston)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**Mentors**

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## Abstract

DeepView Technologies is a company based in Gainesville, Florida, that specializes in robotics, particularly in machines that manipulate tools in severe environments. Our company has designed and built a Remote Operated Vehicle (ROV) which can perform tasks similar to those that were required during the 2010 Deepwater Horizon Oil Rig incident in the Gulf of Mexico. An ROV is a machine capable of being controlled over long distances by a human controller; in our case the ROV mission is to be controlled over long distances underwater. The Deepwater Horizon disaster was caused by the critical failure of an oil rig in very deep water; it caused trillions of dollars in damage to the environment, some of which may never be repaired. Our ROV, "Clean Break," has been designed to effectively and efficiently inspect and repair several episodes of failure on the underwater mechanics of oil rigs and provide accurate information for the environmental effects of any oil leaks. We have several specialized tools designed by our engineers. These include one that is capable of rugged tasks such as cutting pipes and another that is able to delicately retrieve fragile sea creatures without damaging them. During the creation of these tools, we decided that we valued functionality over complexity and aesthetics.

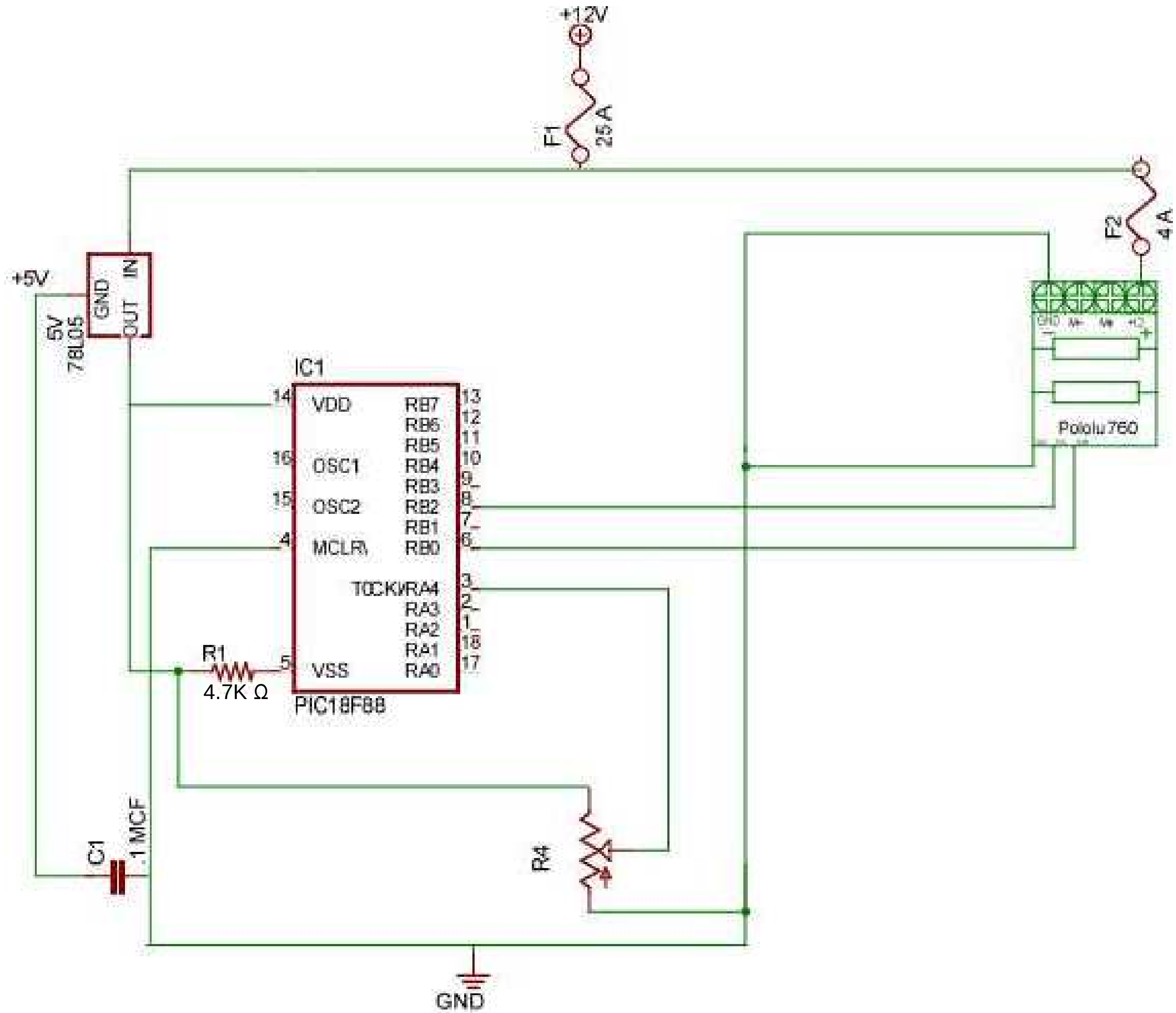

## Table of Contents

# Financial Report

| | Date | Item | Qt. | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| Frame | 12/13/10 | ABS/PVC framing materials | | | $128.20 |
| | 1/18/11 | Returned PVC materials | | | $(8.42) |
| Propulsion | 10/15/10 | Steel ball bearing, double sealed | 1 | $7.13 | $7.13 |
| System | 10/15/10 | Polycarbonate rod, 2" diameter | 1 | $38.70 | $38.70 |
| | 11/30/10 | Brushed thruster | 3 | $509.74 | $1,529.22 |
| Tools | 10/11/10 | Gearbox: stock, standard shaft | 4 | $72.38 | $289.52 |
| | 11/8/10 | Spec tube mobile grease | 1 | $12.19 | $12.19 |
| | 2/25/11 | Altitude gauge | 1 | $128.96 | $128.96 |
| | 3/8/11 | Coupling | 2 | $42.50 | $85.00 |
| | 3/9/11 | Bilge pumps | 2 | $53.09 | $106.18 |
| Video | 10/11/10 | Servo, digital high torque | 1 | $51.00 | $51.00 |
| | 10/19/10 | Micro video camera | 1 | $46.49 | $46.49 |
| | 11/8/10 | Video adapter | 1 | $8.98 | $8.98 |
| | 12/1/10 | Video to monitor converter | 1 | $34.28 | $34.28 |
| | 2/28/11 | Continuous-flex multi cable | 10 | $2.56 | $25.60 |
| | 3/4/11 | B/W CCD micro lens board camera | 3 | $17.99 | $53.97 |
| | 3/4/11 | 100' BNC to BNC cable | 1 | $36.09 | $36.09 |
| Waterproofing | 9/24/10 | Shaft Seal, Type 304 | 1 | $17.00 | $17.00 |
| | 9/24/10 | Self-Align steel flange | 1 | $9.86 | $9.86 |
| | 9/24/10 | Polycarbonate sheet 3/16" | 1 | $9.61 | $9.61 |
| | 12/1/10 | Waterproofing connectors | | | $22.21 |
| | 12/11/10 | Compression unions | | | $5.42 |
| | 1/19/11 | 17.25mm drill bit | 1 | $34.88 | $34.88 |
| | 2/14/11 | 2.5mm O-ring (100 pack) | 1 | $14.47 | $14.47 |
| | 2/14/11 | 70 O-ring (5 pack) | 1 | $4.26 | $4.26 |
| | 10/10-3/11 | Cable Glands, Waterproof Cylinder, Cable (Donated by Dive Rite) | | $120.00 | $120.00 |
| Tether | 2/22/11 | Pair cat 5E riser | 65 | $0.29 | $18.85 |
| | 3/1/11 | 70 feet of used ROV tether | | | $85.00 |
| Electronics | 11/8/10 | Ergonomic joystick | 1 | $56.48 | $56.48 |
| | 12/6/10 | Quick Shot Gen X 500 joystick | 1 | $55.30 | $55.30 |
| | 2/11/11 | LED backlight LCD | 5 | $15.65 | $78.25 |
| | 2/24/11 | Pololu high-power motor driver | 5 | $56.54 | $282.70 |
| Props | 1/17/11 | PVC materials for props | | | $76.45 |
| | 1/18/11 | Flexible coupling | 1 | $7.49 | $7.49 |
| | 1/18/11 | S&D cap | 2 | $2.49 | $4.98 |
| | 1/22/11 | Softbottle 1.0 | 2 | $13.76 | $27.52 |
| | 1/24/11 | Velcro tape | 1 | $3.54 | $3.54 |
| | 1/26/11 | 2 gallon pail | 1 | $3.81 | $3.81 |
| Miscellaneous | 2/3/11 | MATE registration fee | 1 | $50.00 | $50.00 |
| Travel | 6/14-20/11 | Hotel | 4 | $102.35 | $409.40 |
| Expenses | 6/14-20/11 | Meals | 84 | $8.56 | $719.04 |
| | 6/14-20/11 | Gas | 85 | $4.00 | $340.00 |
| Total Expenses | | | | | $5,029.61 |

| Cornerstone Academy ROV Income | |
|---|---|
| Parent's Contributions | $4,468.44 |
| MATE Florida Regionals | $200.00 |
| Adviser Donation | $1,000.00 |
| Total | $5,668.44 |
| Balance | $638.83 |

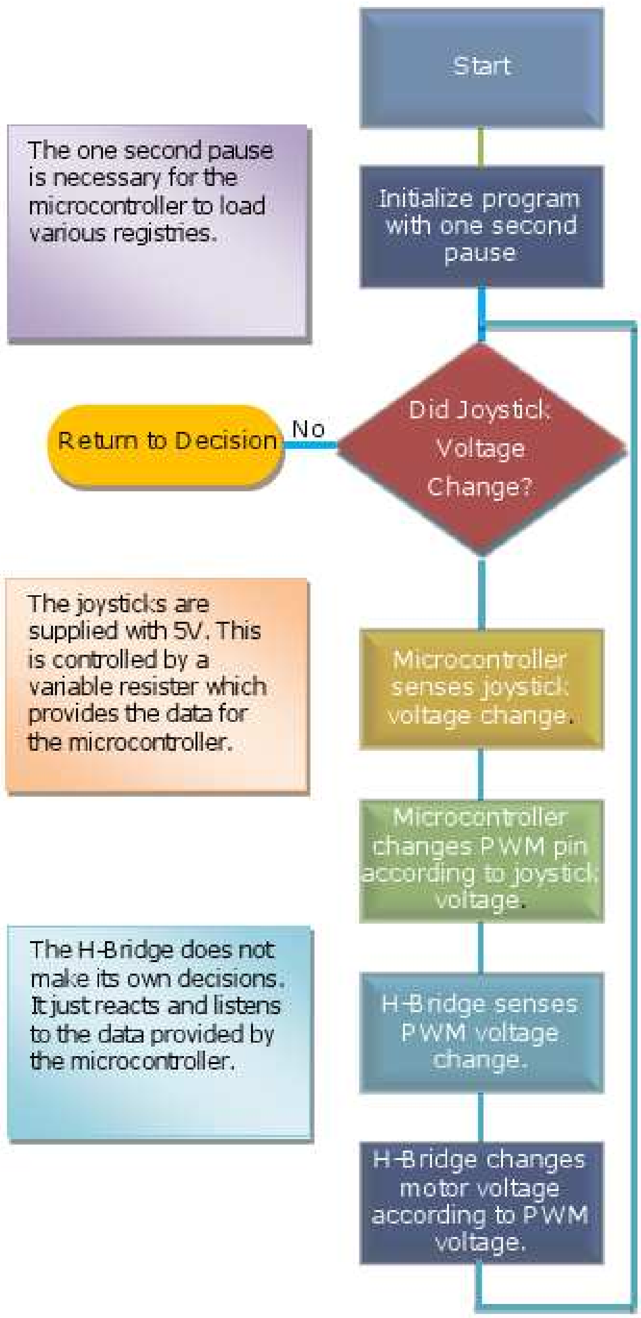
# Electrical Schematics




**Schematic of Control System:** Includes Motor Controller (Pololu 760), Microcontroller (PIC18F88), Joystick (R4 Potentiometer), Fuses (F1, F2), Resistor (R1), and a Voltage regulator (Switch and capacitor). The potentiometer regulates the voltage to the motor controller which changes the thruster speed. The voltage regulator changes the voltage from 12 volts to 5 volts which is what the Motor Controller requires.

# Software Flowchart

This flowchart depicts the process our microcontrollers go through to make decisions. Both joysticks feed into microcontrollers with identical programs.



# Design Rationale: Navigation

Our main objective was to design a highly responsive and functional ROV that utilized simple mechanical devices to accomplish complex missions. Our ROV is highly responsive due to an integration of propulsion, electronics, waterproofing, tether, buoyancy, frame, and monitoring systems. All of these factor into our navigational system, improving maneuverability and versatility. Dubbed "Clean Break", Deep Horizons ROV has performed exceedingly well in accordance with its design.

## Propulsion

Propulsion control is the key to maneuverability. The company's 4 years of experience and two international missions have shown that proportional control of thrusters allows for user friendly control. Our research and development team conducted thruster tests and the test results are as follows in Table 1-1. Compared to the other thruster tested, the Seabotix BTD150 (Figure 1-1) provides between 1.5 and 3.4 more Newtons of thrust at 12 volts with a manageable electrical current. Our latest ROV rendition uses three BTD150 thrusters; two for forward/reverse propulsion and turning, and one for vertical motion. The company relied on modified Rule® bilge pumps (Figure 1-2) for lateral motion because they provided an economical solution as well as created less mass and drag. These simple thrusters supply sufficient lateral movement to help align tools and manipulators.

| Thrusters @12 volts | Forward | Reverse |
|---|---|---|
| BTD 150 Seabotics | 9.6 N | 9.6N |
| Videoray | 8.1N | 6.2N |

**Table 1-1:** The force values of two of the thrusters that we tested.

**Figure 1-1:** A Seabotix BTD 150 Thruster.

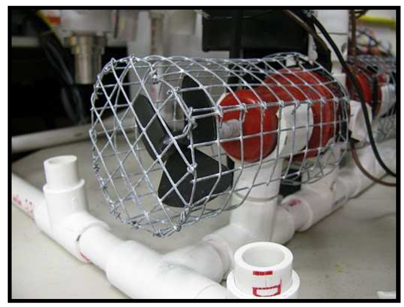


**Figure 1-2:** A modified Rule® bilge pump.

## Electronics

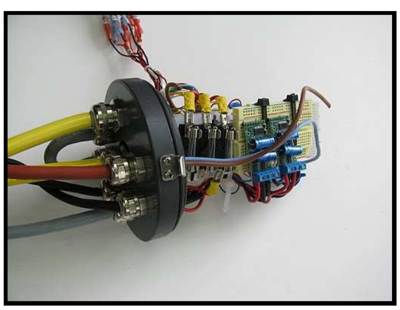


**Figure 1-4:** Onboard Microcontrollers

An innovative component that makes our propulsion system responsive is variable speed control. Our propulsion system has low and high settings which give the operator an intuitive, easily learned joystick control. The forward/reverse thrusters are controlled by separate, self-aligning joysticks. Each joystick has two directions and five ranges of control, a low speed and high speed in each direction and stopped. High speeds are necessary for quick travel to different tasks. Low speeds are critical when performing tasks where "control is speed," -ROV operator, Steve Van Meter. The variable speed control is achieved by PWM

(Pulse Width Modulation) signals from a PIC microcontroller (Figure 1-4). A PWM signal is a way for a chip to create measured digital pulses of on and off to give a variable voltage. Using square waveform, the chip creates a duty cycle (a percentage of on and off) based on the source voltage to give a precise amount of the source voltage. For instance, an 80% duty cycle of 5 volts is 4 volts. This way, the chip can output any voltage from 0 volts to 5 volts very accurately and give us precise control on our ROV. Each microcontroller determines the PWM by converting the joystick voltages (0 – 5 Volts) into a 10 bit value. With forward/reverse motion, variable control is required. However, vertical propulsion only needs manual on/off pulses, which can be provided by a double-pull double-throw (DPDT) switch to operate the respective bilge pump.

## Waterproofing

On-board electronics, one of the main objectives for "Clean Break", is made possible by waterproofing. Every cable to and from our ROV enters and exits our water-tight cylinder which houses all on-board electronics. Our research and development team discovered that in order to have variable propulsion, on-board electronics are essential. If the controller were housed in the control shack, its signal would become unusable because of interference and noise. The motor-drivers translate the PWM signals from the PIC microcontrollers into 12 volt PWM pulses that exit the cylinder and power the thrusters. In order to waterproof the cylinder (Figure 1-5), our engineering team utilized a compression seal with latches and a rubber o-ring. This mechanism allowed us to create housings for cables as well as on-board electronics. Penetrators consist of an internally threaded cap and externally threaded shaft, a rubber insert, and a rubber o-ring. Penetrators (Figure 1-6) were used to create water tight seals for wires into our water tight cylinder. Penetrators create pressure on the o-ring seal. The compression of the seal is the reason they work up to one atmosphere of hydrostatic pressure. When the internal and external parts are fastened together, the combination of o-ring seal and rubber insert are compressed onto the wire running through providing for a water tight seal. The greatest benefits to waterproof circuitry are minimal voltage drop and no short circuiting. With a full load on both forward thrusters, there is a 1.93V voltage drop across the 21 meter tether.

**Figure 1-5:** Water Tight Cylinder

**Figure 1-6:** Penetrators

## Tether

The tether (Figure 1-7) is our Fail Safe Retrieval System (FSRS). The tether provides the communication link between the command station and the ROV. All the information and power passes through it, yet it must be slightly buoyant in order to stay clear of the ROV. Our tether consists of two yellow Videoray cables, three pairs of grey 16 gauge wires, an orange #12 AWG wire and seven black 6mm camera wires. Including buoyancy aid, the diameter of the

**Figure 1-7:** A portion of our tether.

compressed tether is 4cm overall. The two Videoray cables each contain six 28 gauge wires and four 20 gauge wires. Each of the four pairs of 20 gauge wires inside the Videoray cable, along with one of the 16 gauge wires, control on-board tools. Our control wires are the 28 gauge wires that carry a range of voltages, between 0 and 5V, to a microcontroller on-board. A 10 gauge wire carries 12V from the source, a car battery, to the cylinder. This 10 gauge wire provides power to each thruster and on-board circuitry. A plethora of wires becomes an issue when weight is factored in. Backer foam became the quick and inexpensive solution. Generally used as filler for insulation and caulking, it is light-weight, highly buoyant, small in diameter and very long: the perfect solution to necessary buoyancy in line with the tether. The buoyancy created by two strips of this 1.27cm foam counters the weight of the tether.

## Buoyancy

Two-3" (7.62cm) x53cm acrylonitrile butadiene styrene (ABS) pipes serve as the main air ballasts. Located on the outermost, top portions of the frame, the air ballasts provide for a high center of buoyancy on the ROV. Most tools are located at the bottom of the frame creating a low center of gravity. Raising the center of buoyancy and lowering the center of gravity creates righting torque, which ensures the vehicle will right itself in the event of a perturbation. To fine tune buoyancy, Deep View Technologies has developed a system of attaching 9.6g washers on each corner of the frame by placing them on a ¼" bolt, and securing them with wing nuts. This technique of trimming our vehicle gives us the ability to adjust the weight and adapt our ROV's buoyancy to any environment and any water condition. We trim our ROV to have small positive buoyancy, which allows it to slowly rise without any vertical thrust assistance. After finding our ROV weight in water, we used Archimedes' principle to calculate the size of the ABS pipes necessary.

## Frame

The frame of the "Clean Break" consists of a rectangular prism made out of polyvinyl chloride (PVC) pipe (Figure 1-8). We decided to use PVC because of its low cost and modularity. The whole frame measures 92cm x 53cm x 41cm which gives us plenty of room to mount all of our tools but still have exceptional maneuverability. Though smaller sizes were attempted, they did not provide the necessary room for tools. This size gives us enough room to make quick adjustments or furnish add-ons, if needed. In order to retain the benefits of PVC but attain a more robust frame, schedule 40, corrosion resistant PVC made the bulk of the casing. We also chose PVC because we have had experience in making PVC frames. In multiple simulations of catastrophes, PVC frames have earned our recognition as durable and inexpensive ROV bodies.

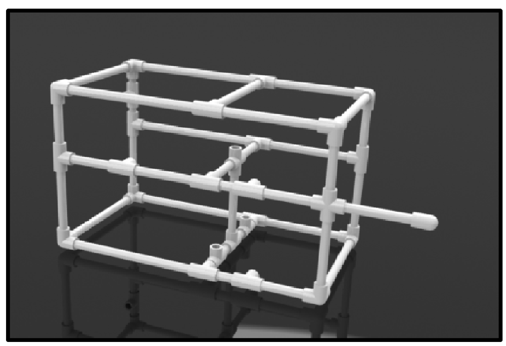


**Figure 1-8:** CAD view of the ROVframe.

## Monitoring System

Though many were considered, Harbor Freight 91309 underwater cameras (Figure 1-9) were chosen. Other cameras tested lacked the necessary viewing angle and showed evidence of spurious false signals and therefore were discarded. Onboard "Clean Break," five cameras are used for navigation and tool operation. For precaution and to avoid disturbance of thrusters and camera view, three cameras are attached in appropriate location on the ROV already attached to various parts. These three cameras are a necessary fall back in the case that a primary fails. Our experienced operators have found that multiple views, or perspectives, of each task and task tool are crucial for timely completion. Also a main camera for navigation and orientation purposes was necessary. The engineering team allocated four cameras for specific tasks. The ease of locating objects in the work area is due to the substantial viewing angle of Harbor Freight cameras, which is seventy degrees.

**Figure 1-9:** A Harbor Freight waterproof camera

## Control Shack

**Figure 1-10:** The control shack

All of the system controls and monitoring are located in the control shack (Figure 1-10). Four single pull double throw (SPDT) switches control three tools and control the power to the control system. Three double pull double throw (DPDT) switches control lateral motion and gripper systems. Overall navigational control is achieved by two joysticks, also located in the control shack. These joysticks are nothing more than simple potentiometers; however, they control thrusters and, thus, are critical. Along with these potentiometers, a DPDT switch controls vertical motion. This vertical switch simply delivers 12 volts to the thruster, giving an all or nothing scenario for vertical motion. Located inside the control shack are three monitors facilitating all necessary viewing perspectives, tool controls, and joysticks within a 70 cm range enabling convenient control by only a single operator. However, for smooth operation, we utilize a tool operator and a main pilot.

## Safety Measures

Not only does Clean Break have several safety measures, but our builders also took extreme precautions during manufacturing. Four circuit breakers are easily accessible located between the power source and the control shack. Banana connectors (Figure 1-11) are attached at the head of the power cable for easy engagement and quick release. A 25A fuse (Figure 1-11) in line with the +12V wire is in place to disengage the power in the case of a short or any other faulty wiring issue that would cause high current. Two switches control power flow, one to the entire system (Figure 1-11) and the other to tool power. When the second switch is inactive, no tools can be operated, thus, no bystanders can be injured. Along with these features safety precautions were used while manufacturing each component. Each tool in the shop requires specific precautions. Safety goggles are required for every power tool from a hand drill to a milling machine. Hearing protection is also necessary for band saw and during the machining of particular materials that can potentially cause hearing loss. When it came to practicing, a constant line of communication was kept to ensure that no one was hurt by tools or thrusters; and while operating the ROV, no one was allowed to be in the pool.

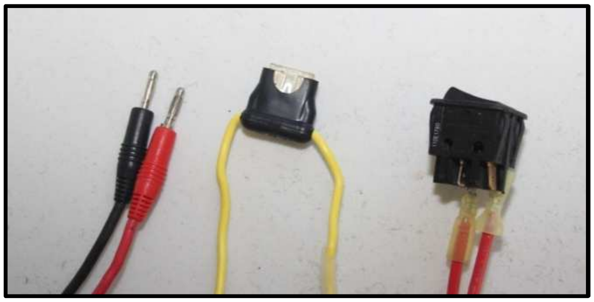


**Figure 1-11:** Banana leads, 25 amp fuse, and safety switch.

## Design Rational Tasks

### Task One: PLRS

Our first task was to remove the faulty riser pipe and stop the flow of oil in a simulated oil spill from an oil rig. In order to do this, our ROV must attach the pipe to an external lift and then cut the riser pipe so it can be removed. To simulate this scenario, we had a U-bolt attached to a PVC pipe in order to fasten a line, and we had two separate pipes connected via a Velcro strip. To create a secure attachment to the pipe, our team decided to use our PLRS (Pipe Line Removal System). This system is composed of a carabiner (Figure 2-1) which is transported by our main gripper to clip onto the U-bolt. In order to move the pipe from the working area, we attached a thin masonry line to the carabiner with added fishing weights to keep the line from getting tangled in our ROV. This choice was fueled by our need for a simple, yet fail-proof system for attachment. However, we needed to modify both the carabiner and the gripper plates because the unmodified carabiner proved unstable when placed in the gripper. This problem was averted with two evenly spaced screws on the ends of the gripper plates and a horizontal rod going through the end of the carabiner (Figure 2-2). The rod is fastened by the two screws, and our carabiner cannot move in the gripper. The gripper we used to complete this task is the main gripper for the ROV and was built by our in-house machinist. Its design and position on the sub made it very versatile and was useful for many applications. In order to power the gripper we used a modified 1100 Rule® bilge pump connected to a planetary gear system. We decided to use a Banebot LLE 64:1 gear ratio planetary gearbox because it offered a compact and effective solution to reducing speed and increasing torque. In order to remove the Velcro strip we added a significant amount of rubber to the end of our grippers using 3M double sided tape and

**Figure 2-1:** The modified carabiner

superglue. This gave us the strong grip and, combined with our powerful thruster, gave us the necessary force to remove the Velcro strip.

## Task Two: Seal Off Oil Flow

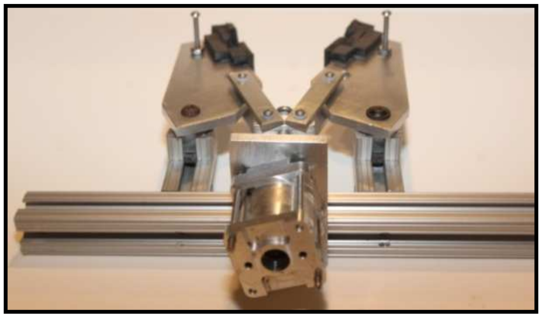


**Figure 2-2:** The Main Gripper with plate modifications.

The second task required our company to insert a hose line into the top kill manifold and then cap the leak by closing the valve and inserting a wellhead cap onto the manifold. In order to securely grip and carry the hose line we needed to modify our main gripper (Figure 2-2). Since the hose line is to be removed and inserted at a forty-five degree angle, we made a special 45 degree cut in our gripper plates. We added rubber padding around the plates so that it would hold the hose line securely in place. We chose this design because it made it easy to remove and place the hose line with the added benefit of creating a tight grip. We had to design two very specific tools to complete the other two missions: turning the valve and installing the wellhead cap. For turning the valve (Figure 2-3), we constructed a similar mechanism as our gripper but attached a different tool head. We used a bilge pump and a planetary gearbox with a 132:1 gear ratio. This gave us the rotational speed we needed to carefully turn the valve. We made the bracket by taking an aluminum sheet and bending it into a “U” shape. This gave us a sturdy prong that would engage the valve handle. To place the wellhead cap on the riser we knew that we would need a very precise tool. To do this we developed our Solenoid Underwater Release System (SURS, see fig. 2-4). This system is composed of a solenoid which uses a magnetic coil to retract and extend a metal support rod. Our wellhead cap is suspended from this support rod. When we want to drop the wellhead onto the pipe, we release the solenoid which pulls the rod out from under the rope, dropping the cap. We decided to use this system because the solenoid is a simple, yet reliable system. This lets us carry the cap on the sub which saves us valuable time. In order to make sure that the wellhead cap would go over the pipe, we had several camera views which let us see exactly where our wellhead is in relation to the pipe.

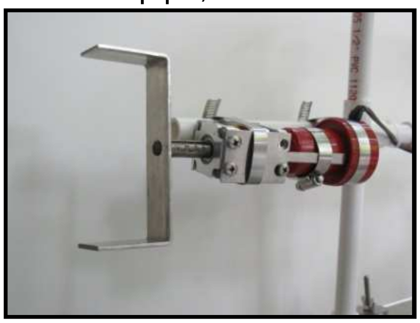


**Figure 2-3:** The Valve Actuator

**Figure 2-4:** Solenoid Underwater Release System

### Task Three: Water Sample

**Figure 2-5:** Water Retrieval System

To measure our depth precisely, we decided to use two Dive Rite depth gauges. We used two so that we would have two vantage points to view from. Also, if one was not working properly, or it was difficult to see because of lighting conditions, we would still have a back-up. A benefit of the depth gauges is that they give a definite reading of whether the ROV is ascending or descending. Occasionally, the camera view is difficult to interpret in this regard. Collecting an undiluted water sample proved to be our most difficult task. To do this we used a bilge pump which was attached to a PVC tube (figure 2-5). In order to get an exact fit onto the water sample, we machined a tapered fitting out of solid PVC to slide onto the bilge pump opening. This enabled us to slowly maneuver the sub into the perfect position as we descended upon the container for the water sample. We used this design and a combination of two camera perspectives so that we could dock quickly and precisely onto the water sample. We used a platypus bag to collect the sample because it is easily compressed which allows for suction of the water into a water tight container.  This design enabled us to efficiently remove the water sample with minimal dilution.

### Task Four: Specimen Retrieval

**Figure 2-6**: The “Snapper”

This final task required us to collect and retrieve three different animal samples from the seafloor. We found out that our main gripper worked well for retrieving the Chaceon crab, however, we needed to design a different tool to collect the other specimen. For the task of retrieving the sea-cucumber our team needed a simple yet effective tool. Hence, the “snapper” was conceived (fig 2-6). The snapper consists of two “L” shaped aluminum pieces held together in the center by a screw. Two ends are connected via a spring which provides the snapping action. The spring provides enough tension to keep the gripper closed. However, when force is applied from above, it opens up to capture the sea-cucumber. This design was chosen for its simple yet effective solution to collecting the sea-cucumber.

## Description of Challenge

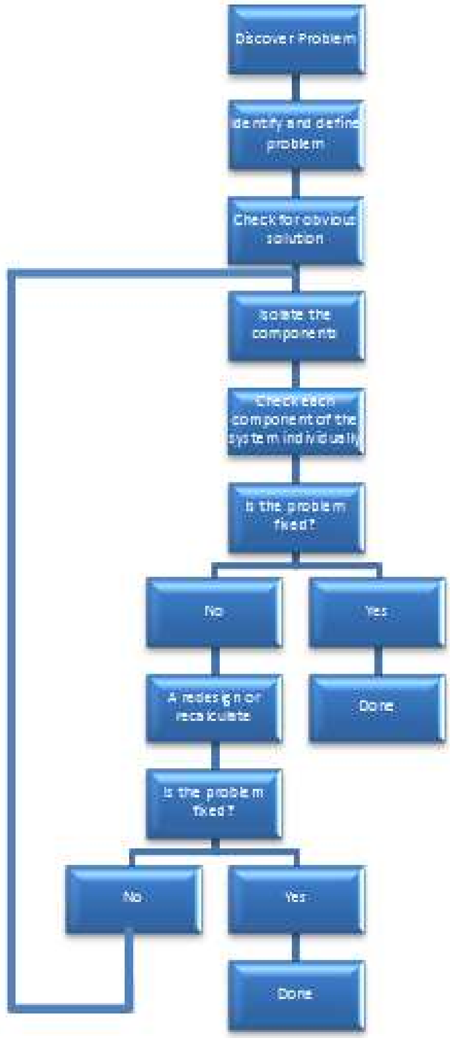
Numerous technical problems arose during the construction of our ROV. The problem we had the most difficulty resolving was the relationships between all the electrical components of the ROV and especially the fragility of the motor-drivers. Each time the coils in an electrical motor or solenoid suddenly switch polarity, the magnetic field collapses before expanding in the opposite direction. An inducted voltage called back EMF (electromotive force) opposes the change in the applied voltage creating a voltage spike that may damage components connected to the circuit. Lenz's Law states "An induced current (or back EMF) is always in such a direction as to oppose the motion or change causing it." This sends negative voltage through all the components making motors twitch or completely turn on. Also, if you have common grounds far away from the battery, the components can affect each other in strange ways.

One particular part of the back EMF issue was between the different motor-drivers. Two of the motor drivers were operated by potentiometer readings, but the third one was controlled by a switch. This switch caused instant collapse of the magnetic field on the thruster and then creation of a new one which sent back EMF through all of the thrusters causing them to go full on for several seconds. This posed a huge threat for navigation because every time we directed the ROV upward we would go uncontrollably forward.

Oblivious to all of this, we created common grounds in the circuitry, as well as connected multiple components together that created back EMF. This resulted in all tools affecting each other to the extent of turning other tools on, as well as damaging motor drivers. We isolated each tool and switch disconnecting it from common ground. Also, we disconnected all switches from the motor-controller portion of the circuit. Once this was done, the signals were cleaner and did not affect each other.

## Troubleshooting Process

If a system fails to complete its mission, the engineering support team must troubleshoot the system. When attempting to find a solution, the engineers must identify the exact symptoms of the problem. Then, once the problem is defined, an attempt is made to check for obvious solutions. For instance: is the power switch on, or is there air in the wellhead cap? Once it is assured that no obvious solution exists, the team then proceeds to isolate the system into individual components. The team then proceeds with the tedious task of checking each component individually for failures that would affect the entire system until the problem is solved. However, in the case that the issue is not solved by careful examination of each component, the engineering team enlists the help of the design team to find a new approach to complete the task. Once another system has been designed and fabricated to replace the failed one, it is then tested and tried on the same task. If it too fails, then we repeat the troubleshooting process until we have created a system that works.




## Lessons Learned

Throughout this year our company has learned critical lessons and improved many essential skills. The most important skill we have acquired is the ability to waterproof our ROV. In the past, our company has attempted waterproofing, but each year we have had to resort to epoxy. Now, however, we are able to waterproof using professional compression seals. This has definitely been a skill gained. Waterproofing the ROV has been a help in so many ways. This has allowed us to have our circuits on board and has enabled us to add motor controller and PIC chips to the ROV. Being able to have PIC chips on the ROV has also allowed us to use joysticks to control the ROV. Using joysticks gives us significantly more control when driving the ROV.

This year we have each developed relationships with each other which have enabled us to work with one another. Even on the days when everything on our ROV was going wrong, and we got very discouraged, we worked together and kept working. This allowed us to fix problems with our ROV. This year each of us have developed considerably more leadership skills from, and a sense of responsibility over, our project rather than if we were simply watching others work.

## Future Improvements

Our ROV, although fairly advanced, has some areas where it is less functional or more difficult to use than others. The primary area the design team plans to improve is the tether. Our current tether is very thick and heavy and adds drag that impedes the ROV's ability in the field. A less bulky tether would improve maneuverability by being lighter and not as stiff. The most effective way to do this is to switch control and feedback signals from wires to fiber optic cables. Fiber optic cables are a lighter and more mobile alternative. With fiber optic cables, the only remaining necessary copper wires would be the two large power wires which supply electricity to the ROV. Fiber optic cables would deliver all data from switches, joysticks, and cameras to and from the ROV. This would not only improve the quality of our signals and allow delicate and accurate information to be sent but also make it possible for us to send more signals.

Another big improvement we would like to make in the future is to make our frame out of carbon fiber. Utilizing carbon fiber would make our ROV considerably sturdier than one made out of PVC. The flexibility of carbon fiber would also allow us to make our ROV in any shape we would want.

In the future we would also like to use pan and tilt for our cameras on board the ROV. Using pan and tilt would keep us from having to use as many cameras. We would be able to see more tools on the ROV using one camera.

## Reflections

### David Shepard

In years before, I have experienced team work first hand. Numerous projects and several national and international recognitions have given me the ability to understand and work well with my peers. This year, however, I have moved up in the hierarchy and claimed CEO. As such, I have had the chance to oversee all aspects of the project, and as an added bonus I've had a hand in all portions of this ROV build. From each tool, to the frame, and onto wiring and waterproofing, I have taken my stance next to my workers. Working from the ground up I have a better understanding of the functionality of our ROV and can give better instruction towards improvements. The leadership skills I have gained through this experience will last beyond this competition and will help me overcome the confinements of petty inability and gleam through to a prosperous future.

### Richard Hurlston

This year, as the CFO of our company, I have been responsible for knowing the financial aspects of our ROV. I have learned much about writing financial reports and keeping money organized as I have been responsible for organizing our finance report. I have thoroughly enjoyed this because I have been able to see all components of the ROV, and I have become familiar with all the information on what we spent on the ROV. Not only have I been working with our finances, but I have also built many things as a junior mechanic. I have worked with every element of the cameras on our ROV. Through close observation, I have learned how to do many more tasks on my own and developed an understanding and confidence such that I do not have to ask so many questions. This has been very integral to my learning and has resulted in an enjoyable experience.

### Greg Spencer

This year I have gained experience with commands and microcontrollers I have not used in the past. Also, I have improved my ability to troubleshoot dysfunctional programs and circuits. In the beginning of the year, it was easy to slack off because the deadlines were so far away, but as time went on, I, and our team, grew in maturity and got the project done. I personally enjoyed my role as our programmer and being a part of all the new technology we have incorporated into our ROV.

### David Sorrels

My experience, as the Senior ROV Mechanic, this ROV was very tedious but even more rewarding. I had two different tasks to complete for our ROV. First, my job was to build a device that could carry the wellhead cap to the designated drop point and release it there. Secondly, I was also involved with the creation of a suction device so that we could successfully take a water sample from the objective. Making these took a lot of time and effort but in the end, the reward of seeing the ROV in the water completing its designated tasks made the journey well worth the work.

### Manuel Angerhofer

Before working as DeepView Technologies Chief Design Engineer, I had taken part in designing structures for other projects. When I became the Chief Design Engineer for DeepView Technologies's newest project, I had to take on much more responsibility and improve my skills. As DeepView Technologies Chief Design Engineer, I helped design almost all of the ROV systems and components. I had to discuss issues with the people building the parts and I would always have to improve our designs. However, it was a very rewarding experience that helped me improve my technical skills and leadership abilities.

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