Technical Report for Nimitz Sr. High School

Renegators Underwater Robotics

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In parentheses

Numbers indicate grade level

(R) Refers to returning members

(N) Refers to new members

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Abstract

Renegators Incorporated is a Texas company and was started with the vision of providing the best underwater robotic solutions and task completion using remote operated vehicles (ROV's). We pride ourselves on listening to our customer's underwater requirements. Our service and cost efficient designs are custom fit to our customer's needs. Our ROV's are specifically designed to perform a variety of tasks including but not limited to collection, repairs, exploration, and inspection. We are aware of environmental impacts that may occur and make sure to build our ROV's to be as nonintrusive as possible. Our ROV, Renegator, utilizes a frame constructed of Ultra High Molecular Weight Polyethylene (UHMW), a tough and almost neutral buoyant material due to its density. Our design was built to be modular so it has the ability to quickly change components with just a few pins to complete the tasks at hand. A 12 meter tether carries power, compressed air and video signals. Four High Definition (HD) cameras are strategically mounted to give us a clear view of our surroundings and tools underwater.

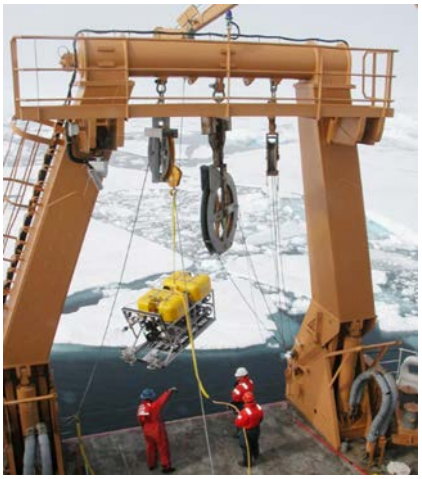
(Left to Right : Christian Castro, Gregory Montelongo, Derrick Tchety, Ruben Valdillez, Emanuel Sanchez, Alcmene Gonzalez, Theophilus Mallet, Nicholas Fogarty, Rafael Soto)

The C.W. Nimitz

The Renegators own and operate its own ROV mother ship, The C.W. Nimitz. Home based at the Port of Houston, Texas, in the United States of America. Our Remote Operated Vehicles are launched from the rear of the Nimitz with its massive A Frame which can accommodate larger ROV's. The ship is 51.8 meters in length and has a 15 meter beam. She is equipped with SONAR, Radar, GPS, Satellite, State of the Art Navigation Systems and a fully functional Machine Shop to maintain our ROV's. She has a double hull design to allow us to work in subzero environments. Her bow has a helicopter pad for any transportation needs.

Our ROV mother ship, the C.W. Nimitz, will be at sea for 30 day intervals. St. John's will be one of the main ports of call for us due to the year round ice free port, international airport and helicopter services that are nearby.

C.W. Nimitz in port



ROV being launched

Company mission

Renegator's, Inc. company mission is to design, manufacture and operate remote operated vehicles (ROV's) in extreme aquatic environments. Our ROV's are modular and built to perform a variety of tasks. We strive to listen to our customer's needs and be the leader in working in the underwater world.

Design

After having our team of researchers obtain background data of the area in which we are tasked to work in, we discovered the average temperature in the water would be -30 to -15 degrees Celsius and concluded that Ultra High Molecular Weight Polyethylene (UHMW) would be the most reliable material to use since UHMW can withstand temperatures up to -150 degrees Celsius. Another reason we choose UHMW because it is easy to drill screws into it. When our research team came together with our engineering team, they established that the best type of frame to build would be "H" shaped. The reason for this is because cube shapes can get caught easily on obstacles and circular shapes can get caught in tight areas; these shapes also have a possibility of confusing aquatic wildlife that the ROV is prey, predator, or vegetation. Inventor 2015 was used to design cut-out patterns that were placed on the UHMW to cut our frame and jaw. After many failed attempts with other types of screws we decided on using a KREG's Jig with 3.175 cm KREG screws to anchor our frame together.

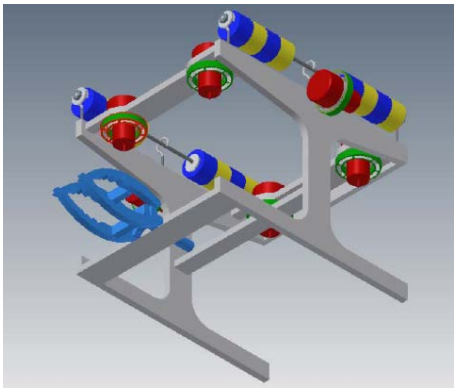
The jaw is made out of UHMW, straps, screws, and bolts that hold the jaw together and allow the jaw's fingers to open and close. The jaw on the ROV has two fingers, one on each side. Originally we had tried using a three finger design but realized after a few trials that having two fingers provided more control and grip compared to the three fingers. We have four high definition (HD) cameras on board: one pointed forward, one pointed at the claw, one pointed towards our collection device, also known as "Anet", for the collection of "algae", and one pointed down at the valve rotator/trolling motor. Each camera is connected by an RCA video connection and is connected to a Digital Video Recorder (DVR) and then to a monitor via SVGA, DVI or HDMI connection.

We designed and built a valve rotator that is added to the bottom of the ROV in order to complete work that require valves to be opened and closed. The motor serves a dual purpose and is a 3785 Litre Per Hour (L/ph) bilge pump motor. It is mounted on a hinge which allows the motor to be moved into either a horizontal or vertical position It gets its power through a double-pull double- throw momentary switch. The switch is wired for reversing polarity which allows a clockwise and counterclockwise rotation. The motor's second function is to serve as a trolling motor when the assembly is taken off and the motor turned into the horizontal position.

With Past years of experience as a guide, we decided it would be best to detach our control box from the cart it was originally stationed on and make it mobile for the sake of weight, size and transportation. With a little more research on Arctic and ROVs we established that there have been incidents in which the ROVs attract predators due to flashy colors. In order to eliminate this problem we decided it would be best to make Renegator a solid black color. We also discovered there is a possibility of fish and different types of aquatic species that would be near the ROV so we rounded the edges off to decrease the chance of damage to any animals or equipment, making the ROV less hazardous

Frame

Our frame was created in Autodesk Inventor 2015 in order to give Renegator the perfect shape and enough space for all components to be attached as well as detached in the case of transportation/shipping restraints. The frame is in the shape of an “H” which was cut out of Ultra High Molecular Weight Polyethylene (UHMW) which is highly durable and is not easy to break or bend. While other companies would use PVC pipe or aluminum as their frame, we found it quite useless and a waste of money to waterproof a material and have to worry about waterlogging. An aluminum frame you also can’t edit the buoyancy after it has been cut, you have to recut the entire thing. Our ROV frame is in the shape of a “H” to give it more maneuverability (see figure 4), a more refined look, and because it removes any excess UHMW that weighs down the ROV. With UHMW being naturally buoyant and super light it is the preferred material used by companies for commercial ROVs, which makes it the best option for us to use for our frame on Renegator.



Basic Inventor Drawing of our ROV

KREG System

In order to connect the frame we used KREG 3.175 cm fine thread screws with a KREG system. A KREG system is a system where a jig is used to drill accurate holes at an angle so the holes don’t bulge out the on other side of the material. With the screw going in at an angle it secures the frame together and gives it a stable connection rather than at a 90 degree angle. Attaching the KREG screw into the UHMW material, we had to correlate the dimensions of the material in order for the KREG screws to sit and fortify the frame from the ROV. In order to keep the ROV from being easily accessed to disassemble the KREG screws are specialized for using a better design on the screw using an Allen wrench than by a Phillips screwdriver.

KREG jig that was used for fastening screws

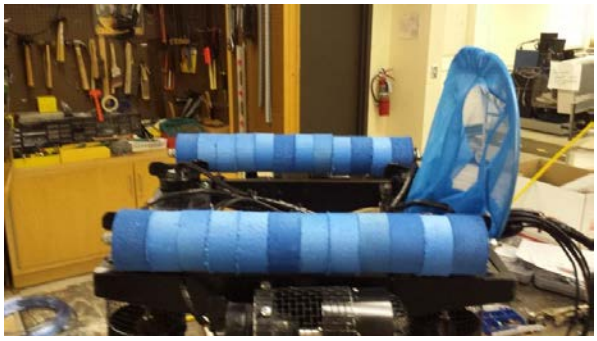
Buoyancy

Our buoyancy system for 2015 is comprised of a “donut” system placed on top of the ROV which is made from the same material as kickboards. The “donuts” were cut by using a hole saw that is 5.08 cm in diameter.

There are holes cut into the “donuts” for all thread to be slipped through. The all thread is then secured in place by large washers and nuts which are then threaded through eye screws at each corner of our frame. By having this system we are able to easily add or subtract “donuts” as needed in order to achieve neutral buoyancy.

On Renegator there are a total of 24 “donuts”, 12 being on each side of the frame. We determined this number through trial and error by first filling up the rods with 12 donuts and then proceeding to remove one from each rod to see how it affected the ROV in the water during our practices. The frame’s material also adds to being able to achieve neutral buoyancy easily since in PVC pipe there has to be holes drilled inside to let out the air pockets that get trapped during construction, but these holes get water inside which creates weight and drag onto the robot. UHMW doesn’t have this problem making it easier to just add our “donut” design on the top and control buoyancy through only one point.

Hole saw cutting buoyancy donuts



Buoyancy system on top of ROV

Propulsion

There are a total of 7 motors on Renegator: 4 to control ascend and descent, 2 on the side to control forward and backward motion as well as turning, and 1 controlling the valve rotator. Each motor uses 12 volts and pulls 3 to 3.5 amps when turned on and .5 amps when idle. Calculating the watts from each of our motors is 36 watts; in addition to all of the motors it adds up to 252.5 watts. The motors used are 3785.4 L/ph (liters per hour) bilge pump motors. The motors are held in place on the frame by using motor mounts, which are made of UHMW and were machined using a Computer Numeric Code (CNC) mill.

There are 4 top motors for controlling vertical movement. Two motors are located in the front and are wired together and two are located in the back and are wired together for attitude control. There is one motor on each side which controls horizontal movement and YAW control.

The propellers were adapted to the shaft of these motors using Master Airscrew MA3200 propeller adapters. The propellers are Octura 1470s which are held in place to the adapter using 10-24 stainless steel machine screws and hex nuts.

Attached to the motor mounts and covering the propellers are shrouds constructed out of thin wall 3 inch PVC pipe and welded wire mesh. Shrouds are used to provide protection from the rotating propeller assembly and to direct the thrust from the propeller. On the end of each shroud, there is a welded wire mesh covering, which was created by hammering a section of welded wire mesh into a hole on a block of wood that was measured to fit around the 3 inch Thin Wall PVC schedule 20 pipe. These coverings are there to protect the propellers from foreign object debris.

Shroud on a motor

Shroud maker

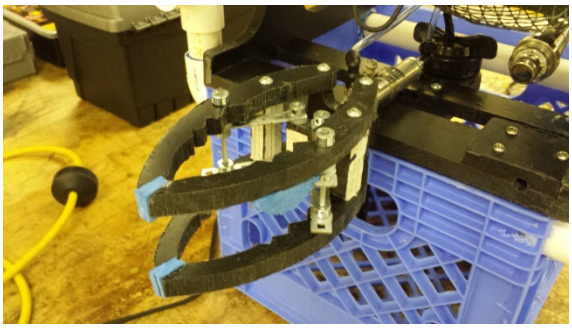
Jaw

There is one jaw on Renegator strategically placed in the front center by a 2.54 cm bore double action air actuator. The design allows us to grab and hold items easily and efficiently. The air actuators are controlled by compressed air regulated at 2.75 BAR. The jaw consists of two parallel pincher arms on each side; we had originally thought of having three arms but decided that two arms gave the R.O.V. better grip after testing.

The jaw was built using UHMW, straps, collars, square rod, stainless screws and nuts. We attached the air actuator to the frame using 2 stainless steel hose clamps, this allows us to rotate the jaw as needed..

Powering the jaw is a 2.54 cm air actuator with a 5.08 cm ram stroke. To open and close the jaw there are two .635 cm air lines which have two top side air toggle switches to control the jaw movements.

Among the various benefits of our design, one, though initially unintentional, seemed to have similarly contributed to the success of Renegator. When we were testing the jaw one day one of our members was able to rotate the jaw at a 90 degree angle. The cylinder shape of the air actuator allows for free movement of the piston inside the tube, in other words there is nothing keeping the piston tightly secured which is why it is able to move. While this was not something we had intended to happen in our design we realized it gave Renegator an advantage in that its jaw movements were not limited; however, the only way to move the jaw is manually.



Jaw on ROV horizontal and vertical

Valve Rotator and Net

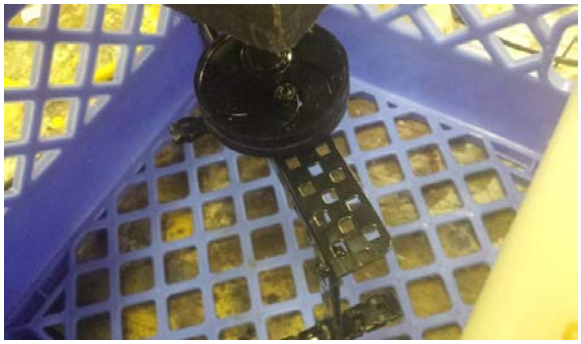
After reading through mission specs that involved the opening and closing of valves we concluded that building some sort of valve rotator would be efficient to open and close the necessary valves needed in the pipeline inspection.

Our finished valve rotator, just like our jaw, is made primarily from a frame rail, straps, gears, bolts. The valve rotator is powered by a 12 volt 3875.4 L/ph black bilge pump motor which is connected through a prop adapter with a drive shaft that has been held in place using J-B Weld epoxy cement. The motor is mounted on a block of UHMW that has been screwed onto the bottom frame brace of the ROV to be able to "sit" the ROV on top of the valves.

We used UHMW so we could have a sturdy, strong hold on the motor as a mount. In using this material it was very important to minimize the vibrations in its centrifugal force, either clockwise or counterclockwise. While in the water, the UHMW will have a stronger hold on the motor and balance out the vibrations in the water.

Our valve rotator is wired on a double pull, double throw momentary switch. By having this wiring along with a potentiometer we are able to reverse the polarity in the motor. Along with the valve rotator we have added a net onto the top of our ROV. Our net comes from a three-pack Ranger net package that we bought at Academy. The net was added to collect the samples of "algae" in the water. The net is attached to the ROV by tightly wedging it between two pieces of UHMW that were already placed on the ROV,and is secured by a hitch pin attached for extra support.

Net used to catch algae



Valve rotator mounted on bottom motor

Trolling Motor

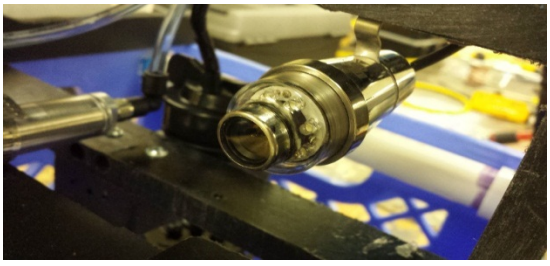
The motor used for the valve rotator can also be used as a trolling motor when in a horizontal position; a trolling motor is a motor that keeps a boat, or in our case ROV, moving at a constant speed.

The idea for this dual purpose motor appeared when our company was going through the RANGER manual and discovered there would be a current of 0.25m/s and a wave that can reach up to 0.4 meters in height during the international competition. A senior engineer had the idea to take a hinge and attach it to a piece of UHMW and use the same motor that would be used for the valve rotator, for the trolling motor.

We attached the hinge to the UHMW and to the motor. The motor runs on the same relay that was used for the valve rotator. We originally planned to have a double pull double throw switch for this component as well, but we feared that the motor would be left in the "on" position and be forgotten, which could lead to a possible mission failure. In the end, we stuck with the double pull double throw momentary switch relay used for our valve rotator

Cameras

The cameras used on Renegator are SS-Aqua Cams that come from the company Lights-Camera-Action based in Arizona. These cameras are of the highest quality being 1080p HD in full color. Although our cameras are expensive we preferred paying more for efficiency and reliability rather than cutting corners and having the possibility of camera failure during a mission. A total of 4 cameras are placed on the ROV: one is facing down at the jaw, one forward, one towards the net, and one facing the valve rotator. The cameras are not rotatable because we believed being able to see all angles at one time was more efficient than having to constantly adjust our view. Each camera has stainless steel housing, runs on 12volts, has white LED lights for dark environments, and has 30.48 meters of wiring to be able to connect the cameras from the ROV to the control box. The luminosity of the lights on the cameras are adjustable through the rheostats that are estimated to be 27.94 centimeters away from the camera's power source.



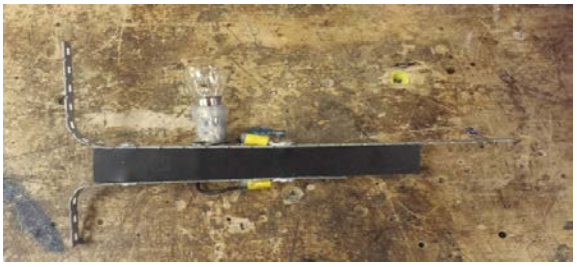
Front camera

Anode detector on front camera

Monitor View of all 4 cameras

Anode detector

To complete the mission in Offshore Production and Maintenance of testing the grounding of anodes we created an anode detector. The anode detector is attached next to our jaw and placed just within the view of the front camera to be able to see the component on screen. The anode detector is made out of straps, a 12 volt automotive light bulb, and a block of UHMW. The straps are attached on both sides of the block of UHMW and bent at 90 degree angles to be able to see if there is voltage. The way to tell if the anode is working is if the light bulb illuminates or not; if it illuminates there is voltage. The two straps have been measured to make sure that they will be able to test the anodes; the upper strap was made longer than the bottom one for more protection on the covered light bulb. The anode detector is connected to Renegator with the use of a hitch pin allowing us to remove it when we are not using it.



Anode detector detached

Anode detector covered and attached to ROV

Tether

The tether consists of 14 wires of 18 gauge stranded wire which carries the power to run the motors on the ROV and are protected by a spiral wrap. Attached to the tether are the video lines that connect to our video monitor and two pneumatic lines that connect to the air actuator operating the jaw.

Tie-strapped onto the tether are “donuts” from our buoyancy system to make the tether neutrally buoyant.

Tether with donuts

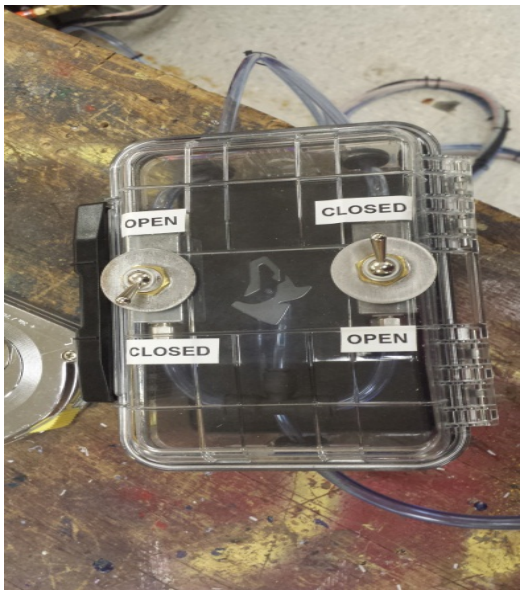
Control Boxes

We have two control boxes: electrical and pneumatic. These control boxes send the electrical and pneumatic power to the ROV components. We also have a digital video recorder (DVR) that receives video signals from the ROV cameras.

The electrical control box is connected to a 12 volt DC power supply that begins with two 25 amp fuses (one at the beginning of the power connection and one inside of our electrical box). The power input connection which goes to a switch and an LED indicator light indicates when power is on or off. Our components for the control box include a safety shut off switch that acts like a fuse in the event that more than 25 amps is pulled into the control box and a switch that acts as a protector and shuts off the system safely to avoid any internal damage to our products.

We used arcade joysticks for directional control of our ROV. The joysticks have micro switches, which when closed control DPDT relays which control our vertical and horizontal motors. These relays are wired in pairs, one relay controls clockwise motor movement and other relay controls counter clockwise motor movement. For safety reasons, these relays cannot be activated at the same time.

The pneumatics control box is connected to a 37.25 liters portable air tank which regulates air pressure to 2.75 bars. The air control box has two air toggle switches manifolds that change the air direction going into the air actuator to open or close it. It is wrapped separately from the tether so that it allows easy access to the wires asides from the power controls in the tether.



Pneumatics Control Box

Electrical control box

Out-of-Pocket Expenses*

			Reporting period
School Name:	Nimitz Sr High School, Houston, Texas RANGER CLASS- Renegators		From: 9/6/2014
Instructor/Sponsor:	David Ericson		To: 4/10/2015

Funds

Date	Expense	Description	Notes	Amount
9/6/2014	Motors	6 Used 1000 GPH Bilge Pump Motors	Used for vehicle propulsion	$ 120.00
9/6/2014	Tether	12 wire different color 18 gauge stranded wire 40 feet	Used for vehicle power to motors	$ 125.00
9/10/2014	UHMW Polyethylene	Black UHMW Polyethylene 4' x 1/2" (3 sheets)	Used for vehicle frame	$ 90.00
3/1/2015	Color Cameras	4 SS Aquacam color cameras- USED	Used for vehicle video	$ 450.00
3/1/2015	Digital Video Recorder	8 channel 1 TB Digital Video Recorder	Used to display video from cameras	$ 249.00
3/1/2015	JAW	Misc VEX robotics parts and 1" Air Actuator USED	Used to open and close Jaw	$ 100.00
9/1/2014	Buoyancy	Boogie Board and 1/4 x 20 All thread/washers/nuts	Used for Neutral Buoyancy	$ 15.00
8/1/2014	Wire Wrap	Spiral Wire Wrap for tether (used)	Used to secure tether wires and wiring	$ 30.00
10/1/2014	Relays	8 DPDT Relays for polarity and power to motors (USED)	Used for vehicle polarity and power to motors	$ 75.00
10/1/2014	Solder/Shrink Wrap and Zip Ties	Solder/Shrink Wrap and Zip Ties	Used to secure wires	$ 15.00
10/1/2014	25 amp fuse/holder SPST Switch	25 amp power fuse/holder and Power Switch	Used to switch and protect from circuit overload	$ 12.00
9/6/2014	Stanley Tool Box	Build control box using tool box as case	Used for Power control box	$ 16.00
9/6/2014	Arcade Joysticks	2 arcade joysticks (each has 4 micro switches)	Used for Motor power and control of ROV	$ 40.00
9/6/2014	LED Light	Red LED light 12volt	Used for showing POWER ON at control box	$ 2.50
11/10/2014	Propellers and Adapters	MA3200 propeller adapters and Octura 1470 Propellers	Used for propulsion for ROV via motors	$ 60.00
9/6/2014	KREG's Screws	1 1/4 " KREG Screws	Used to secure frame together	$ 9.00
9/6/2014	1/4 inch air tubing	3 100 foot rolls air tubing USED	Used for pneumatics and vacuum on ROV	$ 80.00
9/6/2014	Air Switches	4 toggle air ON/OFF switches USED	Used for pneumatics and vacuum on ROV	$ 50.00
	total expenses			$ 1,538.50

* Out-of-pocket expenses are defined as items that are purchased new, services paid for, or items that are "recycled" (e.g. salvaged from your school's e-waste).

Safety Checklist

Pre-Power Up:

- Safety Glasses On
- Area clear of hazard (trip, people)
- Verify ALL power OFF
- Inspection of ROV for anything out of place (shroud being crooked, loose screws, etc.)
- Check Air and Vacuum tanks (37.85 L, releases 2.75 BARS)
- All Team members in their positions and ready to begin power up procedure

Power Up Procedure:

- Power Supply connected to control box
- Air and Vacuum Lines Attached
- Call Out " POWER ON" wait 5 seconds to hear if anyone isn't ready
- Turn Power On Power Supply and Control Box
- Call Out "Testing Motors", wait 5 seconds to hear if any issue, test Motors
- Call Out "Testing Jaw" wait 5 seconds to hear if any issues, test Jaw
- Check cameras for functionality

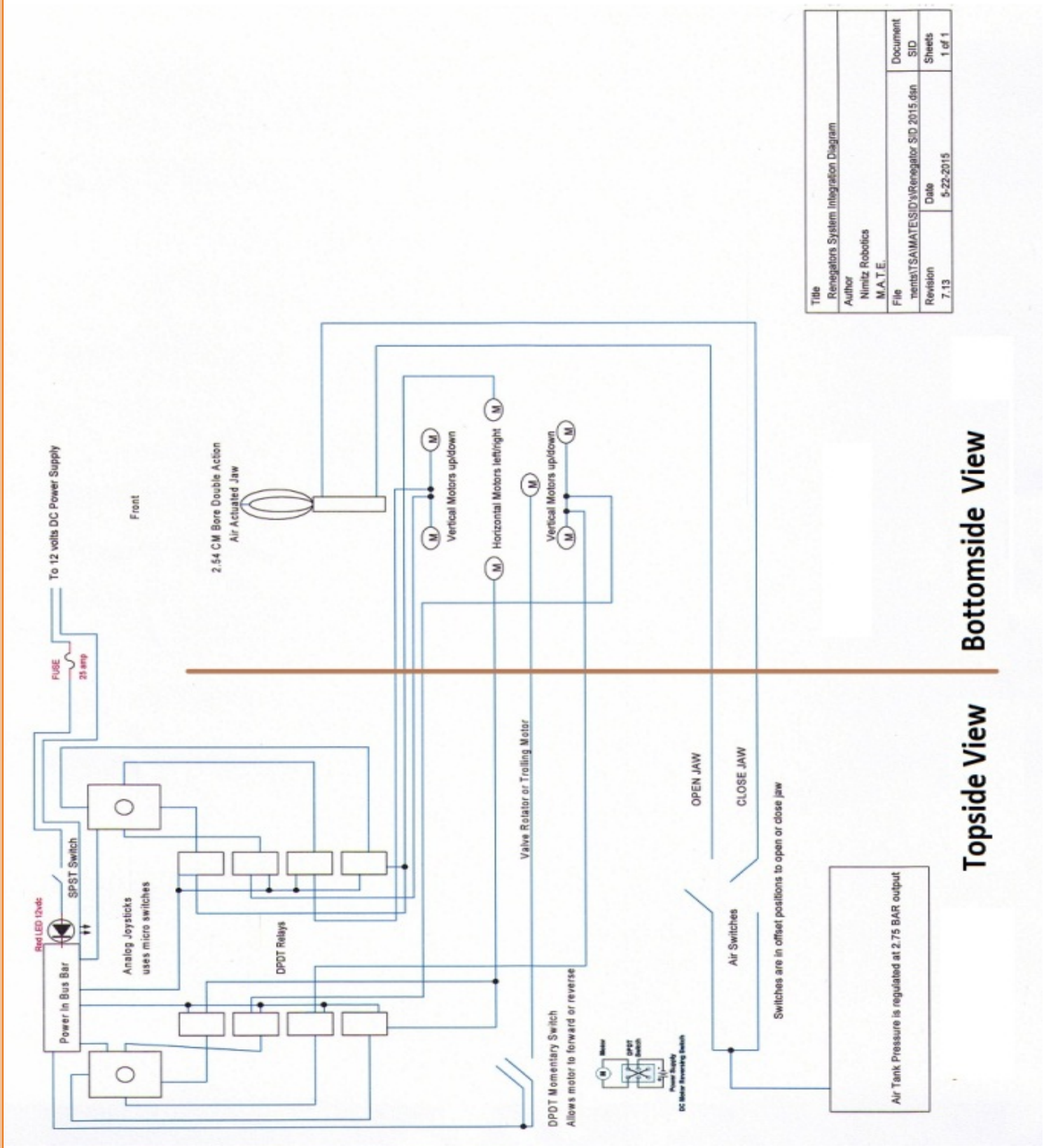
Launch Procedure:

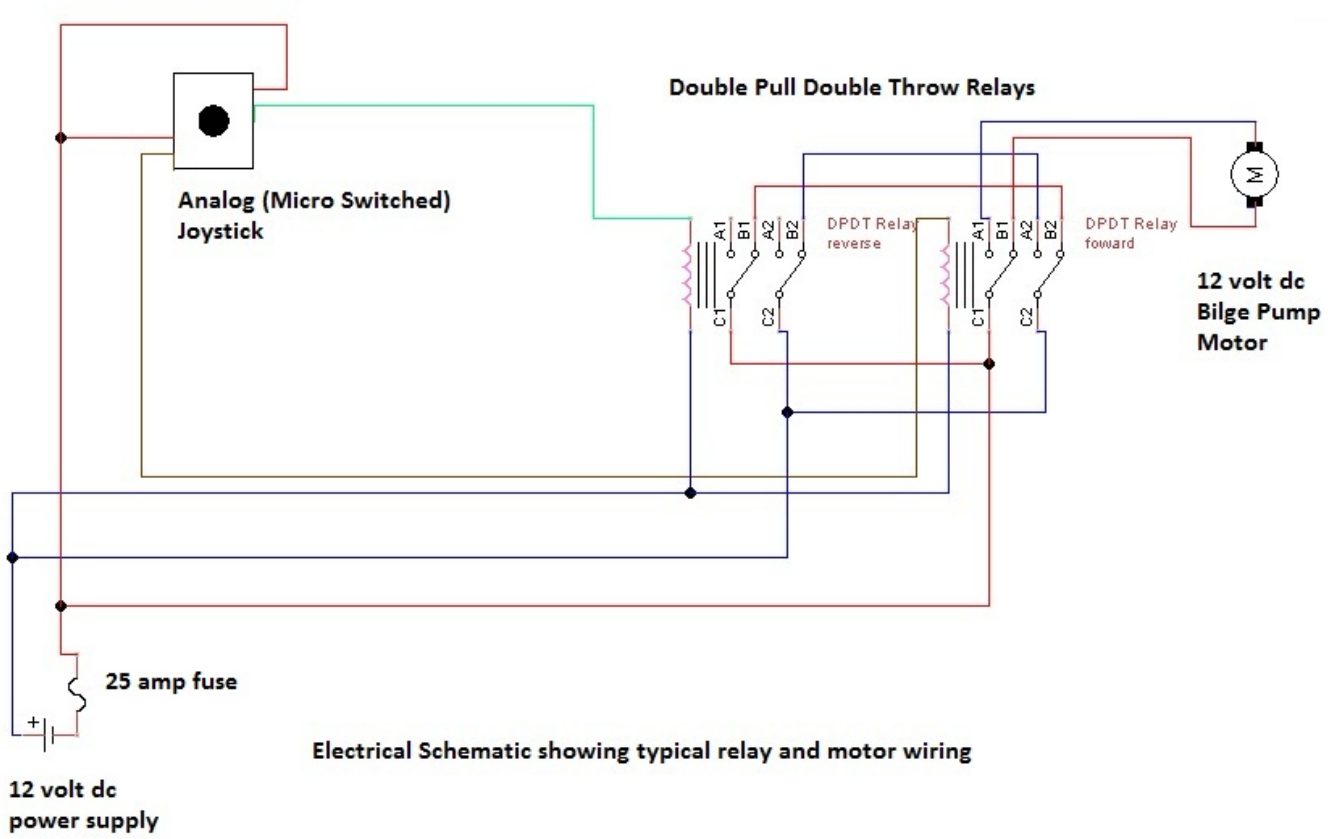
- Call Out "Prepare to Launch"
- 2 Deck Crew reply "Ready to Launch"
- Call Out "Launch" or correct any issues put ROV is water, Perform Tether control

Power Down:

- call out "Activate power switch"
- pilot and copilot replies "Activating power switch"
- pilot and copilot counting backwards from 3
- pilot or copilot hits the power switch and the robot's power is now offline.

System Integration Drawings: Power, Pneumatics and Valve Rotation System





Electrical Schematic showing typical relay and motor wiring

Renegators - Nimitz Sr HS

Reflection

As time goes past, many new things were learned from our experiences as a company and team. New achievements were conquered, new friendships established, and new skills gained. We gained skills in logic, attitude, motivation, work ethic, education, teamwork and leadership. These were instilled into each of our company members. Our unity as a Robotics Technology Family showed us we have the potential to always learn something new and apply it as an advantage.

Future Improvements

In the future we plan on improving our ROV builds by continuing our research and development on brushless motors, incorporation of laser measurement, and exploration of Arduino programming to program our ROV.

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Acknowledgements

Marine Advanced Technology Education

Nimitz High School

NASA

United Airlines

Aldine ISD

Aldine ISD Career and Technical Education

Neutral Buoyancy Laboratory

Oceaneering

Canadian Coast Guard

Memorial University of Newfoundland