aquaPhoenix Inc.

2012 MATE ROV International Competition

Ranger Class

Figure 1: Photo of the Hydroenix

Hydroenix: Technical Report

Chinese International School Robotics Team

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ABSTRACT

The 2012 MATE Remotely Operated Vehicle Competition (ROV) revolves around WWII shipwrecks, and our company has been tasked to design and create a ROV capable of completing an assessment of the SS Gardner, a sunken oil container from 1942.

Our new ROV, the *Hydroenix*, is a complete re-design and improvement of the previous 力 ^{3}, making it the most compact, efficient and manoeuvrable ROV made by the Chinese International School. Through weeks and months of designing, researching, manufacturing, and testing, we have all learned valuable amounts of knowledge regarding underwater robotics, and able to apply it in other ROVs created in the future.

Our five months of work can be proudly shown through the *Hydroenix*. This year, our focus was not only to prepare the best ROV we could create, but also to learn from the seniors of the team, enabling us to continue the engineering spirit within the community after their departure.

The following is the Chinese International School Robotics Team's technical report of the *Hydroenix*. This report holds descriptions, illustrations and explanations of the Hydroenix, including information such as the mechanic and electronic concepts used, how it accomplishes the given tasks, electronics schematics and software flowcharts, troubleshooting information, challenges faced, future improvements and information regarding the World War II shipwrecks and the SS Gardner.

VEHICLE SYSTEMS

With the competition's purpose in mind, the team's focus with this project not merely the missions themselves, but to build a technologically advanced and versatile, underwater vehicular system platform that can be modified in the future to accommodate different tasks and requirements. On top of all that, the robot has been built with a small budget of $5000HKD (excluding research costs), easy to build and use, resulting in many of our own original designs being used in our robot.

One of these original features is the "brain" of the entire robot. Consisting of a self-made circuit board of our own design (further expanded in the design rationale), this "brain" is designed to operate the robot and send sensory information back to the software that is used by the ROV's pilots – all software has been programmed and designed by us, too.

Moreover, the software being used by the pilots includes a system that can easily show system statuses. This is combined with an intuitive controller – a USB flight simulator joystick.

In order to keep the production costs of the robot low, without compromising the overall mission-accomplishing capability of it, we used aluminum, PVC, stainless steel, plastics, and several other widely-available materials to build the ROV, which are all relatively long-lasting and cost-efficient.

Last but not least, the aspect of safety in our ROV has been seriously taken into consideration in our construction process. Basic safety features like a thruster guard and fuses, and also some more complex features such as leakage sensors, internal temperature sensors for overheating detection, digital current sensors to monitor the current flow, and more.

DESIGN RATIONALE – *TASKS*

LENGTH MEASUREMENT

The first mission the ROV has to complete is to measure the length of the wreck. To do this, the ROV has a tape measure attached to it which has a ring on the end. The robot then moves to the other end of the wreck where a camera sees the length displayed on the tape measure and is recorded by a team member on the poolside.

ORIENTATION OF SHIPWRECK

The second mission involves determining the orientation of the ship on the seafloor. This task is relatively simple because it only requires the robot to maneuver itself to be in line with the shipwreck. An on-board compass is in viewing range from the camera, which allows us to determine the orientation of the ship on the seafloor.

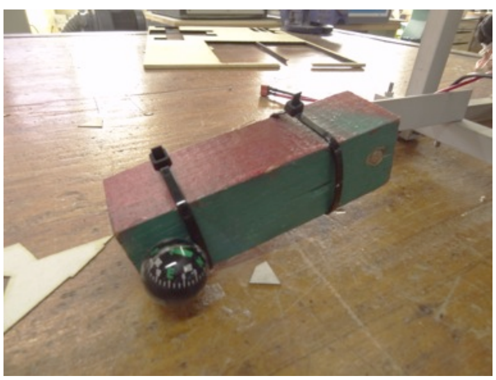


Figure 2: Compass used for determining ship orientation and metal detecting

MAP OF WRECK SITE

The third mission involves drawing a map of the wreck site. To do this we move the ROV around the wreck site and use a camera mounted so that it faces directly downwards. Using the information from that camera a map is drawn by a member on a poolside

METAL DETECTOR

To determine if debris piles are metal or non-metal, we use the compass attached to the ROV. The ROV is maneuvered so that the compass is not pointing north to ensure that we do not get confused over what is metal or not, then the ROV approaches the debris pile and if the compass suddenly changes direction when we approach, we know that the debris pile is metal. The advantage of this system is that it allows us to get a result without having to precisely maneuver the ROV.

SONAR

To scan the shipwreck with sonar, all we need to use is the camera on the ROV, the ROV moves into place and because of the way motors are mounted diagonally, we can control the position of the ROV very precisely.

LIFT BAG

The next thing we have to do is to transport and attach the lift bag, we use of two of our robots systems, the manipulator and the solenoid attached onto the top of the frame. An extension, which secures itself onto the lift bag, has an extension which houses the shaft from the solenoid, the hook is then clamped into the manipulator. With this set up the ROV manoeuvres to the U-bolt on the mast and hooks on the lift bag.

Following off the last task, the lift bag is already in place and ready to be filled with air. An air tube ends right under the air tube so that when air is pumped through the tube it will bubble up into the lift bag. When the lift bag is ready for release, the manipulator lets go of the hook and the solenoid is deactivated leaving the lift bag free to float up onto the surface with the fallen mast.

TRANSPORTING CORALS

To transport the endangered corals, we use the manipulator. The ROV manoeuvres in front of the coral and grabs the coral. The ROV is then moved to a free square to drop the coral.

At this point the ROV is resurfaced, the air tube which was used to inflate the lift bag is moved outwards and the piece which is used to reseal the hole is placed into the manipulator.

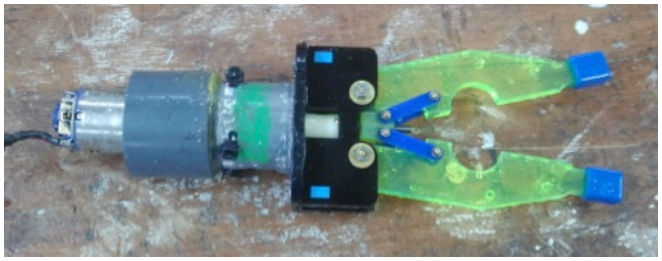


Figure 3: The manipulator, capable of transporting the corals.

SIMULATED SENSORS

To determine whether or not fuel oil still remains in the tank, the two simulated sensors are attached to the frame of the ROV, the ROV then manoeuvres so that the sensors can touch the desired area.

FUEL SAMPLING

To remove a sample of fuel oil from within the tank, we use the same air tube used to fill the lift bag. The tube is pushed through the gel, a small cap on the end of the tube to prevent gel from clogging the tube; a pump is then used to draw out a liquid sample and is stored in a reservoir.

Figure 4: The pump (left) and reservoir (right) to collect a fuel sample.

RESEAL HOLE

To reseal the hole, we use a cover which has already been placed into the manipulator when the ROV resurfaced; the ROV manoeuvres so that it faces directly to the hole and then it moves forwards to attach the cap, the manipulator then lets go of the cap and the hole has been sealed.

When returning the sample to the surface, we do not need to do anything because of the design of the suction system. The design of the suction system means that the sample is directly brought up to the surface which means we can see if our sample is of good enough quality and quantity, if not we can immediately take another sample because the ROV is not required to surface.

DESIGN RATIONALE – *MECHANICS*

FRAME

The Hydroenix's frame is an aluminium cube, with each side 39cm long. We chose aluminium because it is sturdy and light. Aluminium is rust-resistant, making it a suitable material to use to build an underwater ROV with. It is also easy to cut and shape, which makes it straightforward to modify if needed. The modifiable cube design allows us to easily attach new tools or features, which a useful because it makes it easier for us to attach the tools needed for completing certain tasks. The compact frame easily fits eight thrusters, our circuit box and various other tools which makes our robot very space efficient and mobile underwater. The aluminium frame makes our robot lighter and thus also makes it easier to control in the water.

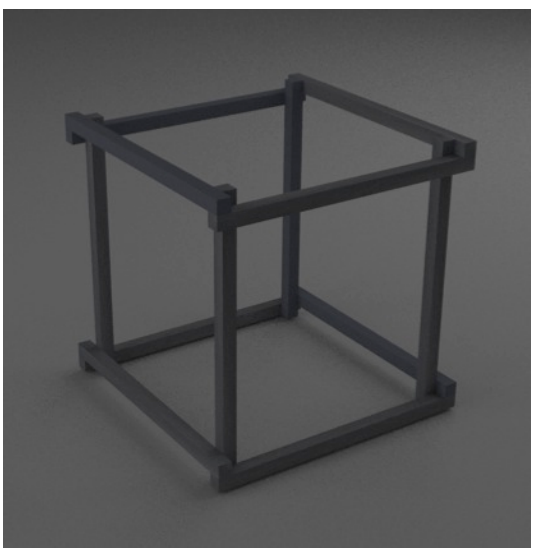


Figure 5 - Render of frame without components

PROPULSION

The propulsion system is composed of eight 1100GPH waterproof bilge pumps, four which are used for vertical movement, and four providing horizontal movement. Each motor has an individual channel, allowing precise movement, relative to the four-channel design of the 力 [3]. Each motor is fused with a 6A fuse, to prevent over current when the motor stalls.

One of the main differences between the Hydroenix and 力 [3] is the angular positions of the motors. This year, we have decided to angle all the horizontal motors at a 45-degree angle. This is to allow the ROV to move in many more directions, and is able to not only yaw, but also strafe, which is a feature that the 力 [3] did not include. We used higher quality propellers this year, and have a propeller extension to increase efficiency. Each thruster is capable of giving 4N of thrust, allowing a faster and more powerful ROV than the 力 [3].

Each thruster requires 4A at full throttle, with a total of 32A required to run all motors at the maximum limit (voltage drop over tether is not considered). However, we do not need to worry about blowing the 25A fuse, as there is voltage drop over the tether, and not all motors will be activated at full throttle simultaneously.

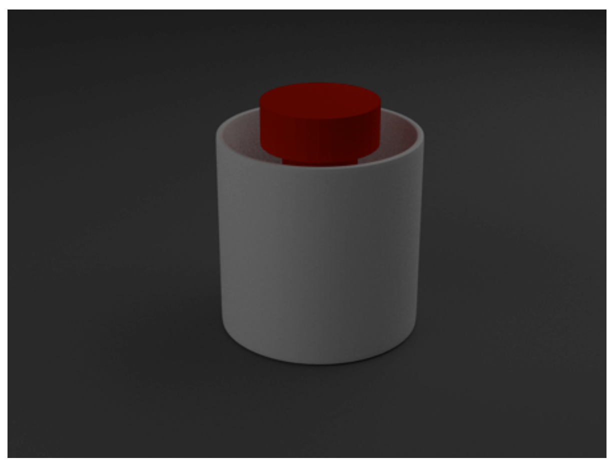


Figure 6 - Render of motor shroud with motor

TETHER

The Hydroenix's tether consists of a total of seven cables, 16 metres long. For powering the ROV, the tether includes a +12V power cable and a ground cable, both respectively split into two cables in parallel to minimize the resistance within the cable. Two Category 5 (CAT5) cables are used for serial communications and signals, each cable holding four pairs of wires. An additional airline has been incorporated to allow the Hydroenix to complete the given tasks, as well as provide a slight bit of buoyancy to the tether, allowing better manoeuvrability.

The tether has been braided together to allow greater flexibility, and has buoyant flotations to prevent the tether from sinking. Metre marks have been placed to allow the approximate amount of tether left, and allows the tether to be used efficiently.

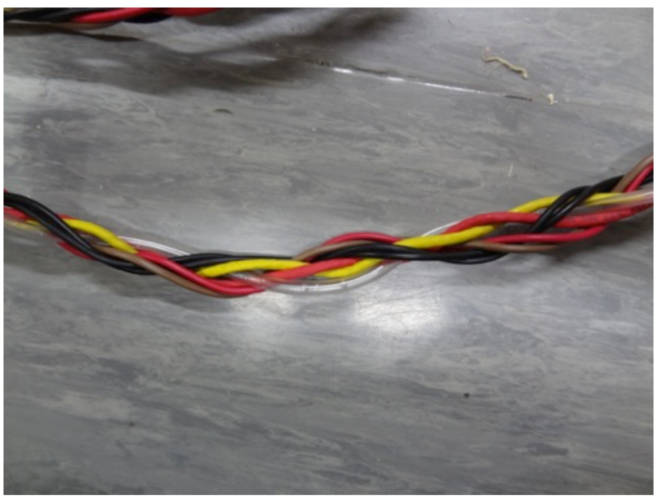


Figure 7: The cables and air tube used in the tether.

UNDERWATER HOUSING

There are two inexpensive, waterproof boxes on the Hydroenix which has holes on both sides, one side connects to the tether and the other side connects to the systems on the Hydroenix. Inside a terminal is used to connect all the wires. To ensure that no water gets to the terminals, liquid wax is poured into a hole drilled into the cover and let to set, when dried it ensures a totally waterproof housing because there is simply no space inside the box where water could leak into. This system was made opposed to the design in the 力 [3] because there are no places where water could leak in, however in the underwater box of the 力 [3], delicate electronics were placed, therefore not allowing this method to be used.

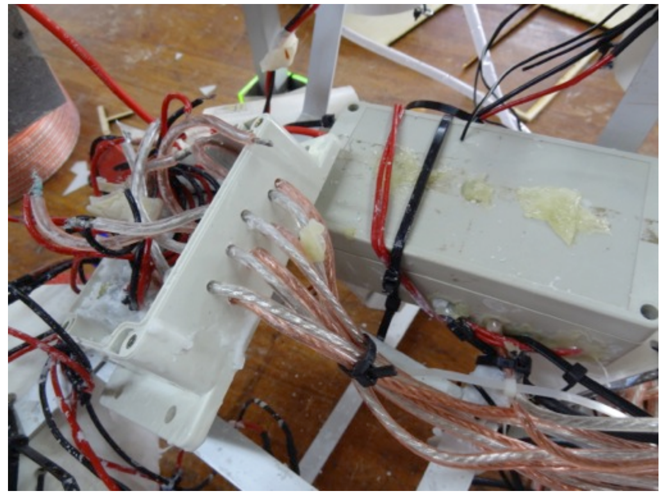


Figure 8: Image of Underwater Housing

MANIPULATOR AND ACCESSORIES

This year's manipulator has expanded on the 力 3, having better control, and a less powerful motor. Upon testing the previous manipulator, we found that the motor was too strong and would rip the connecting sections between it and the claw itself. In addition, the motor was not completely waterproof, and was in danger of rusting. In order to improve this, we had the motor completely replaced. Now using a bilge pump, it is weaker but more reliable, as well waterproof. However, the entire claw had to be redesigned, but we did manage to make improvements to the gear system, as now the motor drives a worm screw rather than simply a screw, which allows the main piston to move up and down and thus open and closes the claw itself.

When attaching and inflating the lift bag, we were required to bring down a lift bag and attach it to a fallen mast. The lift bag is a PVC pipe with a knocked out end cap on the top end and a hook on the bottom end. To secure the PVC pipe onto the robot so that it does not move in other directions, we made a device that extends the lift pipe so that we can attach it to a solenoid. The device is cut out of 9mm acrylic and comprises of two parts, the two parts wrap around the PVC pipe and uses cable-ties to securely clamp onto the lift bag. Electrical tape is also wrapped around the device so that it grips onto the PVC pipe more tightly. This extension is attached to the frame with two small cylinders that fit loosely into the frame, what this does is that it keeps the lift bag from rotating and makes managing the lift bag much easier. Floats are added on the extension so that the lift bag is also neutrally buoyant.

To collect samples of fuel oil from the wreck, we made a pump system to suck fuel oil from the ROV, up the tether and onto a reservoir located on the poolside. The system is made up of three parts, a pump, an airtight box and the tube, all three which are connected together. The tube that is attached to the ROV sucks the fuel oil up because a partial vacuum is formed in the airtight box by using the pump to pull air out. Both hoses are connected to the top of the box so that even when there is liquid in the box, there is still air space to create a vacuum and continue to suck liquid up.

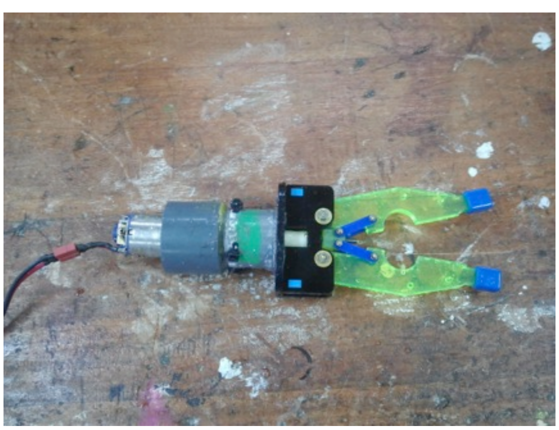


Figure 9 - Initial manipulator design

SAFETY

When making our robot, we were aware of how safe our robot is to handle and in this process we have added certain features on the Hydroenix to help maintain our awareness of safety hazards.

Starting from the outside of our robot, there are bright yellow safety stickers placed on the motors and electronics box on the robot to remind the handlers to be careful when the robot is turned on. In addition, the Hydroenix has safety guards on all the motors to ensure that no sea animals, debris etc. get stuck in the motors when the robot is in motion underwater. These may seem like small things, but aquaPhoenix Inc. makes sure to take extra precautions when dealing with safety. Another example of the detail and effort we put in safety are all the edges of the frame that have been sanded down to ensure no one will be accidentally scratched or hurt themselves when handling the Hydroenix.

We have also seriously considered precautions when handling the ROV. This includes ensuring the ROV is powered off and disconnected when transported, and also to keep away from any moving parts whilst it is in motion.

As a part of ensuring our safety when handling or operating the Hydroenix, we have come up with a safety checklist, which we can go through every time we test the robot:

When transporting the ROV:

- Make sure the tether is neatly coiled
- Everything must be placed on a trolley where it won't slip off easily or hand carried
- Follow designated roles

When setting up:

- Unravel the tether from its coil
- Securely plug in the tether to the topside box

- Ensure that all motors, cameras and other task accessories are securely attached on the ROV and are fully functional

When operating:

- To make sure not put fingers near the motor guards when the motors are running
- To keep an eye on the tether and untangle all knots formed (if any)
- To make sure we have enough tether by keeping an eye on the meter marks

DESIGN RATIONALE – *ELECTRONICS*

MOTOR CONTROLLER

The motor controller used in the Hydroenix uses the same concept as the ones in last year's 力 3, but it has been greatly improved to allow finer, more sensitive control. In our aim of making the ROV more modular, we have decided to create individual motor control boards that will fit vertically into a slot on the motherboard. This will make it easier to carry out maintenance, and if one board breaks, it can be easily replaced. Each board contains two motor controllers, because most of the Integrated Circuits (IC) used contain two channels. With twelve motors to control, there are a total of six motor control boards in the ROV.

The crucial part of each motor controller (for one motor only) consists of a Double Pole Double Throw (DPDT) relay and a n-channel MOSFET. The relay has been wired up so that it will change the direction of the motor by switching the connection of the motor's terminals between the power and ground. The MOSFET uses the PWM signal from the microcontroller to control the voltage feed to the motor. Low Rds(on) MOSFETs have been used to lower the voltage drop of the transistor, and thereby its heat dissipation.

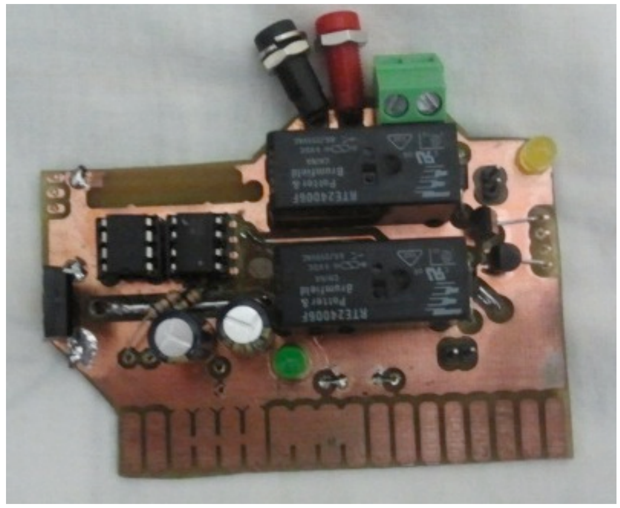


Figure 10: Completed Motor Controller

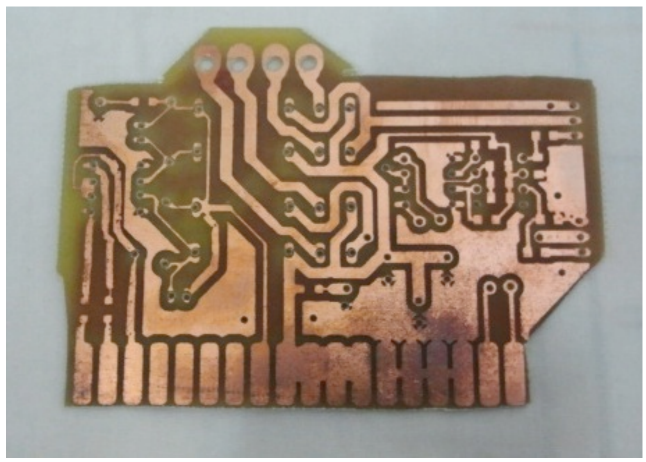


Figure 11: Motor Controller PCB

The improvements that were made to this year's motor controllers are the use of a MOSFET driver and optocouplers. The problem with last year's MOSFETs were that every transistor's gate has a certain capacitance, so with the limited current output from the microcontroller, it takes a while for the gate to charge up and most likely cause the MOSFET to be "off" for a short time. To accurately switch the gate of the MOSFETs, a driver has to be used to supply the gate with the required current to prevent the delay caused by the charging. The optocouplers are used to create an electrical isolation between the noisy motors and the sensitive ICs (like the microcontroller) to increase their stability.

CONTROL UNIT

The motherboard is in charge of connecting all the different electronic modules together and distributing the power to the different components. It is divided into four major parts -- motor control boards, voltage regulator, connector jacks and microcontroller and other ICs. There are six 2x18 card-edge slot connectors that are in charge of securing the motor control boards in place, supplying them with power (+12V and +6V) and to forward the signals of the microcontroller to the boards. To prevent the terminals from melting and fusing with the motor control boards, multiple terminals have been placed in parallel to lower the amperage each one has to handle. The voltage regulators (L7806 & L7805) are an essential part of the Hydroenix's electronics; it converts the incoming +12V (maybe even lower due to the voltage drop across the cable) to +6V for the relays' coils and +5V for the ICs. The connector jacks are for connecting the power lines, CAT5 cables and I2C sensors to the board, and the microcontroller and ICs are connected to the board via header pins.

SURFACE ELECTRONICS

The topside box handles the cables in the tether - the power cables and the Category 5 (CAT5) cable. First is the main power cable, which connects to the power supply given. 13A switches are used to control the power to the robot, and we chose to use two switches in parallel, as a 13A switch will blow when 25A is passed through it. Putting two switches in parallel will divide the 25A load between the two switches, thus lowering the total current each switch has to handle the 12.5A. A 25A fast blow fuse then follows this as it can safely protect the electronics and the power source. The ground cable connects directly to the mains. An ammeter and a voltmeter are connected to the power cable for monitoring.

The CAT5 cable is for our cameras and serial communication between the computer and the robot. The first two wires are for powering our first camera and the third is for camera signal, which is connected to RCA input into the monitor. The next two are for powering our second camera and the sixth cable is for camera signal for camera 2.

All these are encapsulated in a strong PVC box that is able to accommodate all the components such as the voltmeter and the ammeter.

The switch and motor control box are two modes of control. The switch box is our backup plan and was used in the regional competition in Hong Kong. It is a PVC box in the same dimensions as the topside box. Switches are installed on the top of the box for control of the movement of the robot. One switch is used to control vertical movement, and two others are for left and right respectively. Two more switches are used for the solenoid and the manipulator. The switches are in DPDT switches, allowing bi-directional control with the connections formed in a H-Bridge.

The motor control box houses the main board and the motor controllers. This mode of control is PWM control, which allows variable speed control. Furthermore, more features, including strafe, are now capable through trigonometric calculations, allowing greater freedom of the ROV. The box contains fans to ensure the motor controllers and the main board stay cool when they are running. The benefits of this are that it is easy to switch between the modes of control if one system fails during the competition.

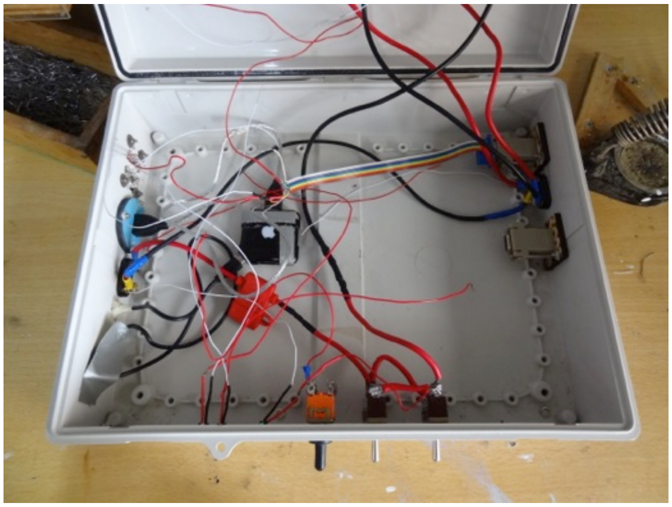


Figure 12: The inside of the surface electronics box

Figure 13: Image of the Motor Control Box

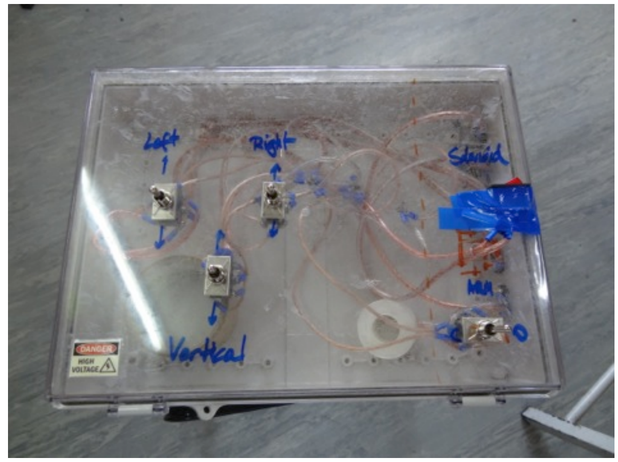


Figure 14: Image of the Switch Box

DESIGN RATIONALE – *SOFTWARE*

PYTHON

The Python programming language is used for the Hydroenix's topside software. It is a very powerful language, and its simplicity and intuitivity allows many of the members of our team to be able to use it whilst creating powerful programs. The topside software is in charge of reading the joystick input, calculating the required motor strengths and sending and receiving data from the ROV. Unlike last years 力[3] software, this year's software is not multi-threaded, because threading is an advanced field of programming and most of the junior members who wrote the software does not understand. Therefore, this year's software runs only on one thread, and it has been optimized to reduce the effect of it on the processing speed, which is 12ms per run loop at its lowest and 30 at its highest.

There are three main modules of the software - the joystick communication, motor control and serial communication module - and they are executed in order in every run loop. The first module is in charge of requesting and reading the joystick data and storing them in a buffer that can be accessed by the other modules. The second one is an algorithm that calculates the required motor strengths to achieve the motion passed on by the joystick. The last module is in charge of sending the motor strength data and receiving and processing the sensor data to the microcontroller on board the ROV.

A software flowchart can be found in the Appendix.

ARDUINO

The microcontroller used in the Hydroenix is the Arduino Mega 2560. It uses the atmega2560 chip and runs on AVR-C software, which is ROV's poolside software. The Arduino is in charge of reading the incoming motor strength data from the computer and and sending it to the individual motor controllers through its 12 PWM pins and 40+ digital pins. It is also in charge of reading the data from the I^2C sensors and sending them back up to the computer.

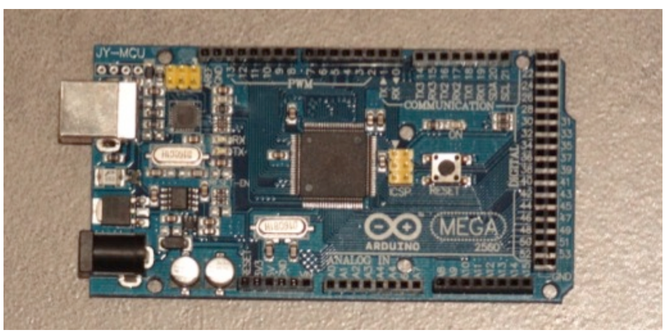


Figure 15 - Image of the Arduino Mega 2560

Figure 16: Image of Joystick controller

TESTING PROCEDURES

When testing the ROV, there are four stages: set-up, test runs, troubleshooting and pack up. Our setup stage includes setting up everything and having it ready to go in 5 minutes so that we can practice our setup. The test runs involve using props to test the functions of the robot, a person will be swimming in the pool to assist in moving the props and spotting problems, but otherwise the swimmer and the pilot will not be communicating to ensure realistic circumstances. The third stage will be troubleshooting, where problems are found and fixed, if the problem cannot be fixed at the pool then it is noted and then repaired when the test run is over. The last stage is packing up where we practice taking the ROV out and moving everything to simulate the pack up time we get during the competition.

TEAMWORK AND COOPERATION

This year we recruited a few more new members on our team, which made it even more important for us to cooperate with each other to ensure that we could work together to complete our goals and deadlines on time for the competition. We worked well in terms of as a team, because we were mostly motivated and interested in the same things. For many of us, this was a chance to share our experiences and expertise from last year's Robotics competition with the new members.

We created shared documents and spreadsheets to ensure that we could see the progress others are making on their tasks. Overall, teamwork has been successful in our company through constant communication with each other and a friendly, enjoyable atmosphere.

FUTURE IMPROVEMENTS

One problem we had this year was that the design of our robot, particularly the electronics and software of it was quite complicated and space-consuming. With the use of optocouplers and MOSFET drivers, a lot of the junior members of the team do not know how they work and thus don't know how to debug or install them. To reduce the size of the electronics and make the electronics simpler, we can use motor H-bridge ICs that are very small and easy to use.

Also, another improvement to have in the future is better organization and time managing, to ensure that we have sufficient time for all aspects of our ROV. To do this, we may have to draw out a detailed plan at the start of the year, so that everyone will have a job at any stage of the manufacturing process, and the manpower can be evenly distributed.

TROUBLESHOOTING

In every project, problems will always occur at different parts of the manufacturing stage, no matter how well the design is. For example, even though the schematics of the motor controllers have been simulated in an electronics program (Yenka), it still did not work the first time we tested it in real life. Throughout the process of making the Hydroenix, we have encountered numerous problems, both big and small.

The biggest problem that we have encountered is the problem with the RS-232 serial communication, and we approached this problem with trial-and-error because we did not know what was wrong. When we first connected the microcontroller with the computer, the ROV did not respond to the data the computer was sending it, and the computer was not receiving any of the sensor's data. When we opened a terminal program, we noticed that the information coming into the computer was not in the correct form and the microcontroller will freeze for a few seconds when we tried to send something to it. Confused, we started probing multimeters and oscilloscopes into the different part of the serial circuit, comparing the circuit to online schematics and datasheets and tried debugging it with small-scale "Hello World" tests. Finally, we noticed that the power supply of the max232 chip was very noisy when we analyzed it with the oscilloscope. We therefore added the biggest capacitor we can get into the Vcc (power) and ground to decouple it, and it worked!

CHALLENGES

A huge challenge this year was time management. This year, the senior member of the team was very busy because he is graduating this year. This meant that a lot of the work was passed to the less experienced junior members of the team, which took longer to get going. Also, there were many more new members of the team this year, which meant time had to be taken to train and teach the new members. All this affected the state of the robot.

The problem of time was compounded with the problem of the lack of coordination within the team. Often, one member of the team could not get his job done because of lack of components or specifications needed for the job to be completed. This meant that our team lagged behind schedule and we could not get anything done.

Although we encountered these challenges which were only avoidable from the start, we have all still tried our best to accomplish the tasks given to us.

ABOUT SHIPWRECKS AND THE *SS GARDNER*

More than 8,500 oil carriers lie not just on only seafloor, but also in the Great Lakes and other bodies of water. Over 6,300 of these ships were sunk during the World War II period. The volume of oil and other dangerous cargo on these ships has been estimated to be anywhere between 0.5 and 4.3 billion gallons.

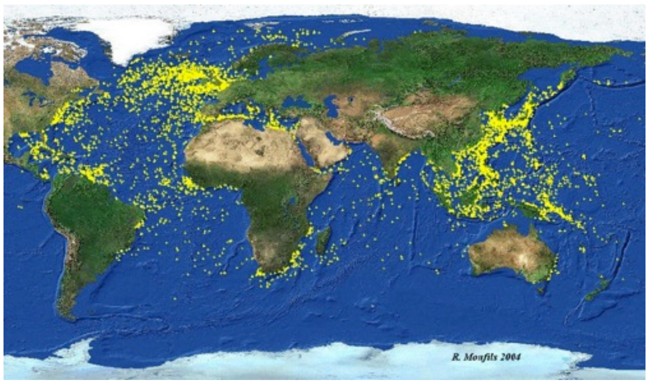


Figure 17 - Location of sunken WWII ships

The oil and hazardous cargo on these shipwrecks pose an environmental problem, for they can potentially pollute the oceans, endangering marine life.

The state of the shipwrecks are hard to assess, with limited budgets, time and resources, and a great number of sunken vessels. Time is an important factor affecting the condition of shipwrecks. As more time passes since a ship sank, the more the wreck will deteriorate, and the higher the chance of oil and other cargo polluting global oceans.

One example is the *SS Jacob Luckenbach*. This vessel sank on the 14th of July, 1953, after colliding with its sister ship. At the time, the *Luckenbach* was carrying 457,000 gallons of bunker fuel. Over the years, the *Luckenbach* has deteriorated and started to leak oil irregularly. The *Luckenbach* is located 27 km southwest of the entrance to San Francisco. This is a very problematic location, for during certain seasons, a large number of sea mammals and birds gather. Costs for salvaging and other related work considering this shipwreck is 19,200,000 USD. However, the *Luckenbach* is named a historical resource under the Natural Historic Preservation Act (NHPA), and the National Marine Sanctuaries Act (NMSA) has claimed this vessel a protected resource. The *Jacob Luckenbach* project was successful, removing all oil within reach.

Figure 18 - A bird affected from the mysetery spills linked to the SS Jacob Luckenbach

The *USS Arizona* in comparison, is in a terrible condition, leaking oil for 60 consecutive years into the Pearl Harbour (currently leaking 2-9 quarts a day). This vessel is also protected under the NHPA, and any operation to disturb the wreck must be in accordance to the terms set by the NHPA. This vessel's condition is monitored.

Figure 19 - The sinking of the USS Arizona

On Christmas day, 1942, while the *SS Gardner* was travelling off of Cape Canaveral, it was hit by a German U-boat and sank on the same day. At the time, there was no evidence of major leaking or spill. However, the concern is growing that time has taken it's toll on the hull of the *Gardner* and potentially causing the oil that remains on board to leak in the near future.

People have also begun to question the state of the oil that remains on these sunken vessels. Rather than a flowing liquid, the oil may have become a tar-like substance that cannot be easily removed from a tank.

The missions this year revolve around these real-life issues. Task 1 focuses on assessing the shipwreck (missions involve determining the length and orientation of the shipwreck, mapping the wreck site, determining if debris is metal or non-metal, and scanning the wreck with sonar). Task 2 concerns the oil remaining in the hull, and endangered coral (missions involve transporting, attaching and inflating a lift bag to make a mast float to the surface, determining if there is oil remaining in the fuel tank, extracting a sample of the oil, resealing the fuel tank, and transporting endangered coral off the shipwreck and onto the seafloor). The MATE competition may be unrealistic, but it still allows team members to have the same experiences as professional ROV engineers, and broaden our knowledge concerning WWII shipwrecks.

REFLECTIONS

Ryan Mok, Year 9

My second year of being on the school robotics team was as good as an experience as a first one. This year, more members have been recruited to our team, allowing us to work better collaboratively this year, and to also try new things that we could not have done in the past.

This year, I have learnt a lot more regarding the electronics and programming behind the ROV, and the importance of these sections. Robotics has taught me a lot about engineering, which I believe is an important skill; and it is interesting to see what can be put together through hard work and dedication.

Although I believe that we have worked better in the previous year, I still believe that overall we have all put in our best effort to make the robot work. Despite the fact that two-thirds of the senior members have been unable to help out this year, I am still happy with the ROV we have created. Even though we may not do so well this year, the skills learnt this year will definitely be of great value next year.

Ariana Barreau, Year 10

As my second year in being in the Chinese International School's Robotics team, I am happy to see that more and more students and teachers are taking an interest in what we do after hearing about our accomplishments. I feel that seeing this has pushed us to aim to do well in these competitions to continue to inspire and to help make people be aware of the fun and learning experiences you could have in being in the Robotics team. This year our team has worked very hard to improve and create a new robot that is compact, light and efficient. I feel that all of this hard work will pay off, since this robot can be easily used for next year's competition.

Being in the Robotics team has helped me learn to be more of a team worker, especially now that we have new members in our team, I have been able to meet new people that are interested in the same things as me and learn to cooperate with all my team members.

Stephen Liu, Year 9

This is my first full year being in the Chinese International School's Robotics team. I feel that I have learnt a lot this year. I have learnt a new programming language and a lot about electronics. Not only has being in the CIS Robotics team given me more technical skills, but it has also given me collaborative skills. I have learnt how to organize myself and accomplish the goals set for me to complete the greater goals of the team. I have learnt how to interact with others that have the same interests as me not only on a level of friendship, but also on a professional level. I believe the technical and the collaborative skills the CIS Robotics team has given will equip me for the future. I will certainly try to continue with these skills next year where I also hope to learn more.

漢基國際學校
Chinese International School

FINANCIAL REPORT

	Part	Quantity	Unit	Reused value (HKD)	Donated by	Cost (HKD)
Electronics						
	Arduino Mega	1				459
	MAX232	1				12
	DPDT Relays	6				96
	N-channel MOSFET	6				48
	Fuses	8				16
	MOSFET Drivers	2				60
	Misc electronics (resistors, capacitors etc)	N/A				200
	Copper clad boards					312
	banana connectors + crimps					208
	Sensors	4				400
Tether	Black and red 10AWG	30	Metres	246.06		
	CAT5	15	Metres	147.64		
Mechanical	PVC Boxes	3				624
	Aluminium square tubes	3	Metres		CIS	
	Stainless steel screws	12		402	CIS	
	USB to Serial dongle	1				30
	CCD Camera	2				298
	3, 6, 9mm acrylic	N/A			CIS	
	500 GPH Bilge pumps	2			CityU	
	Motor mounts	8				124
	1000 GPH Bilge pumps	8			Trac-Marine	
	Propellers	8		64		
	Misc. (Screws, standoffs, copper piping)					822
					Total:	3709

ACKNOWLEDGEMENTS

The Chinese International School ROV team would like to thank the following people and organizations for supporting us, allowing the creations of a successful ROV.

Mr Trevor Harris – our teacher supervisor, for being there when we needed help.

Mr Anthony Bernardo

Mr Glen Morgan

Ms Karen Ward

Mr Mark Hayes

Chinese International School Design Technology Department – for allowing us to use their machines and storage area, and for donating materials (scrap and new) for the construction of the ROV.

CIS DT Technicians – for being there as moral support, and occasional advise with technical difficulties.

And last but most certainly not least...

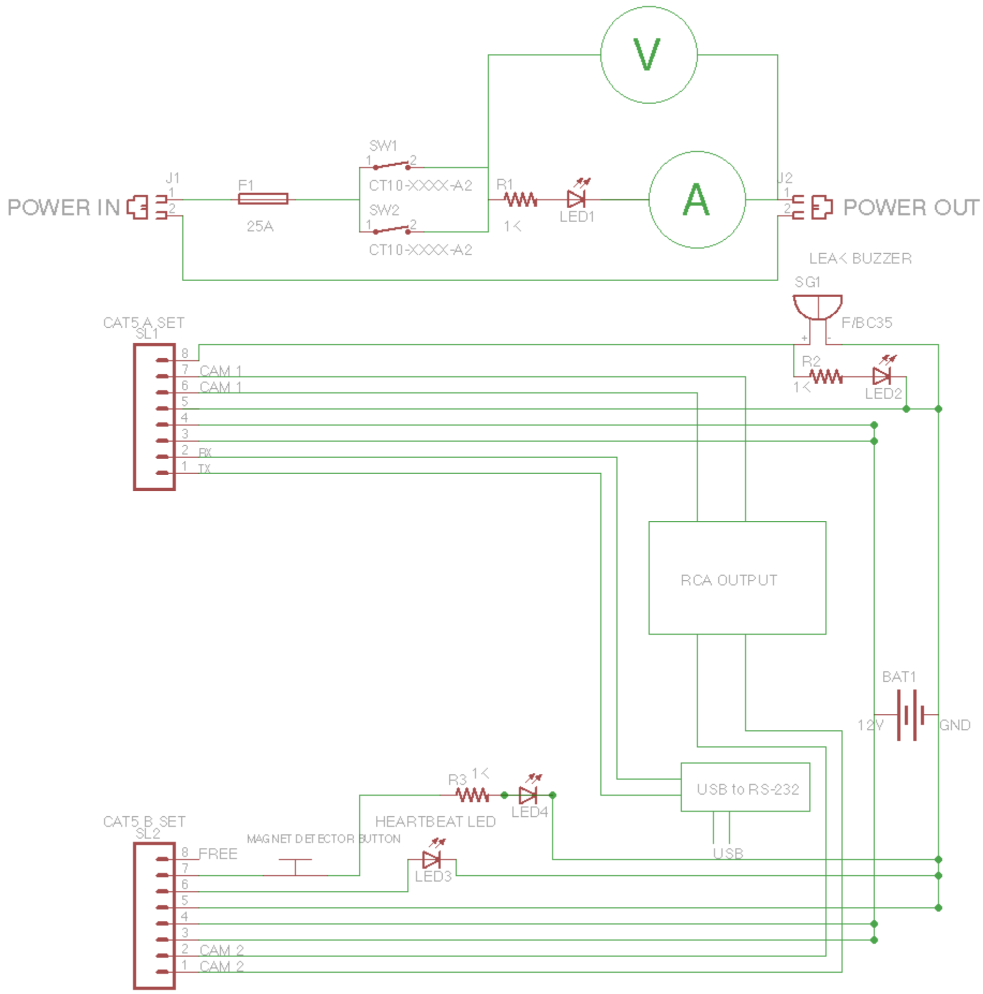
MATE Marine Advanced Technology Education Center – for giving us this wonderful opportunity to not only expand our technical knowledge, but also to teach us real life working skills such as teamwork, to hopefully strengthen our knowledge and prepare us for a better life after high school!

REFERENCES

"World War II Valor in the Pacific." *nps.gov*. National Park Service U.S. Department of the Interior, 4 Apr. 2012. Web. 15 Apr. 2012. <http://www.nps.gov/valr/faqs.htm>.

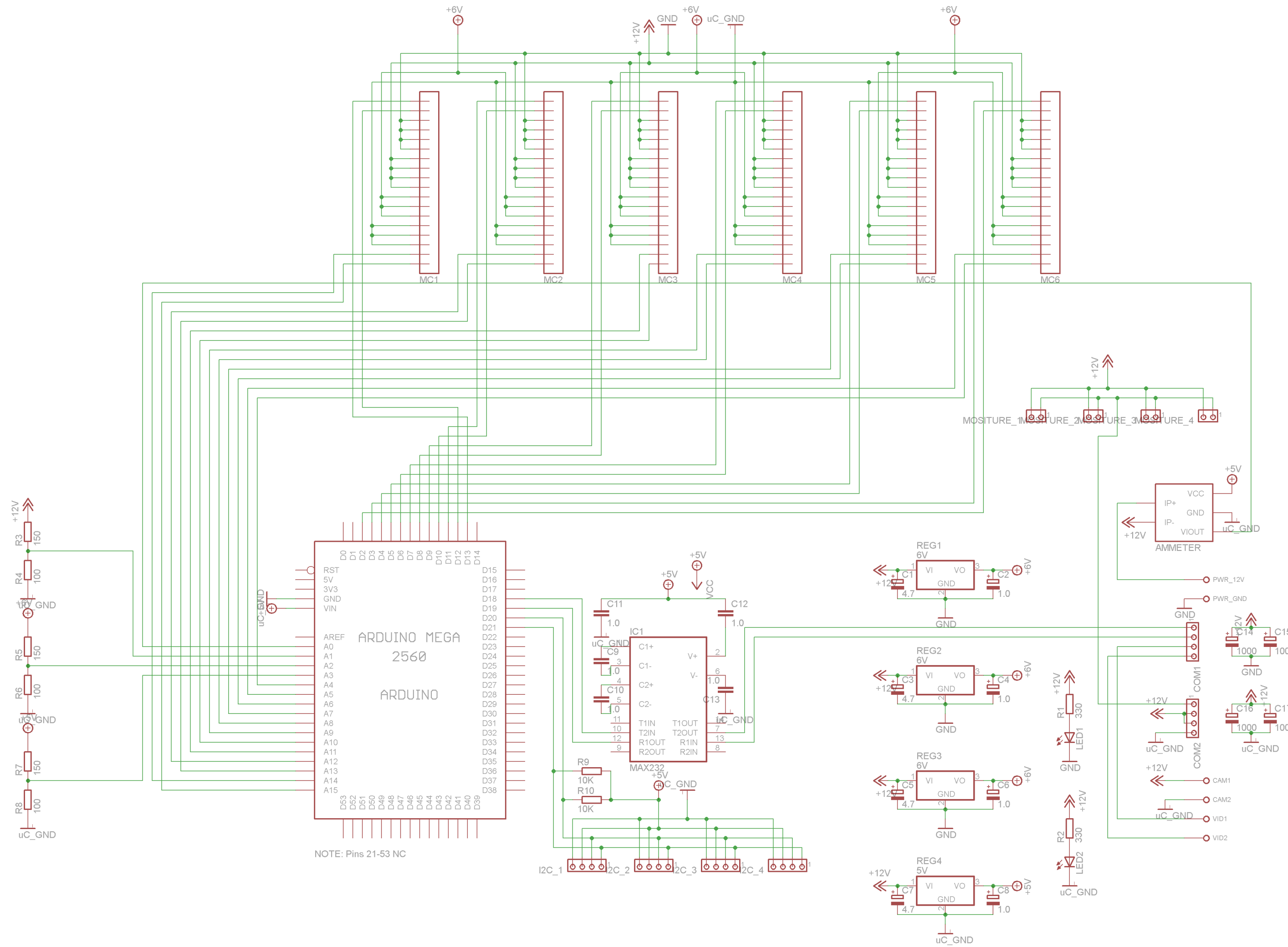
APPENDIX

TOPSIDE BOX



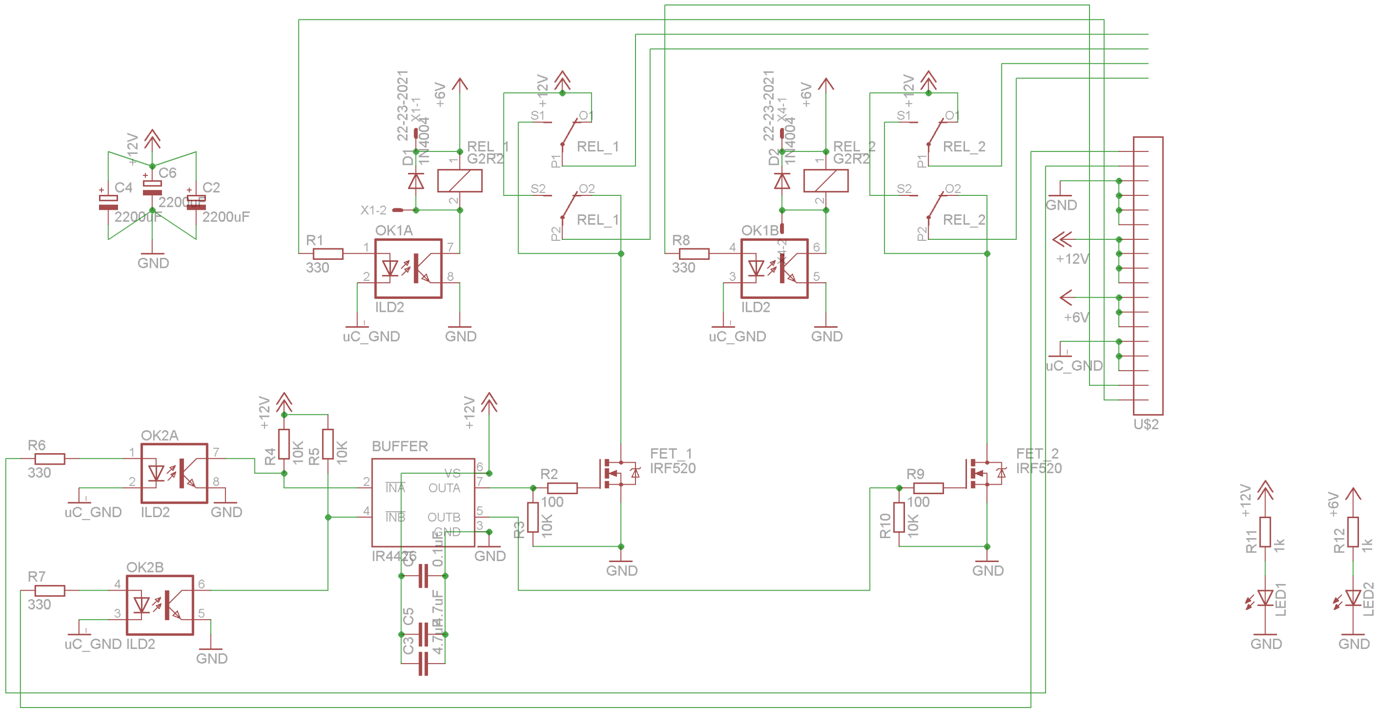
This shows the basic schematics of the topside box. The power goes through the box, passing a 25A fuse, two switches in parallel, a voltmeter, an ammeter and a LED, prior to powering the tether. Also, it shows the connections used for the CAT5 set used.

CONTROL UNIT



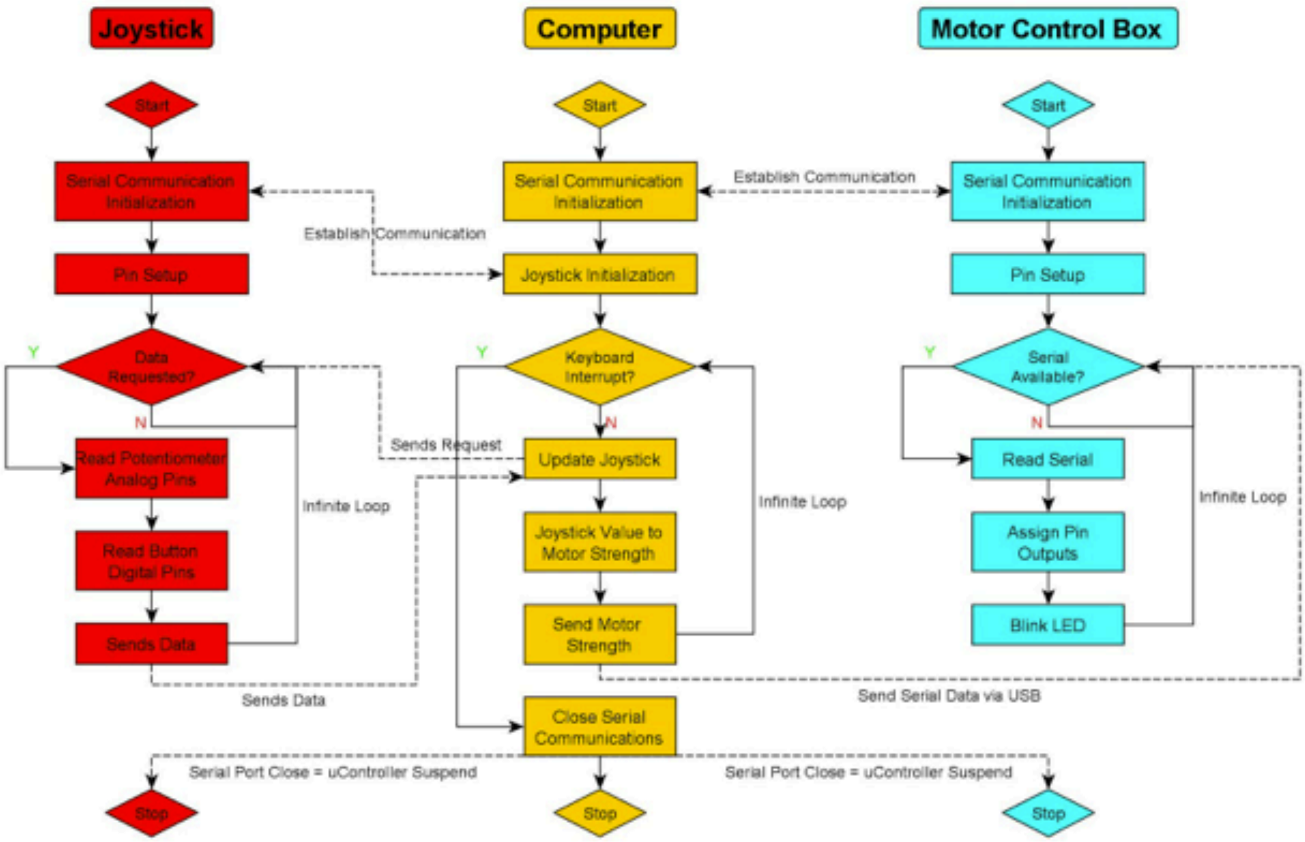
The control unit holds the microcontroller, as well as the slots for the motor controllers. Also on this board are the important components such as the voltage regulators.

MOTOR CONTROLLER



The motor controller slots into the control units on the main boards. It holds the important components which cause the motors to change directions and turn at variable speeds, which are the relays and the transistors.

SOFTWARE FLOWCHART



The Serial Initialization stage occurs when the software is run. The Python software then enters an infinite loop, where it reads the serial from the joystick, converting these joystick values into motor strength values, and then sending the motor strengths back to the Arduino through serial.