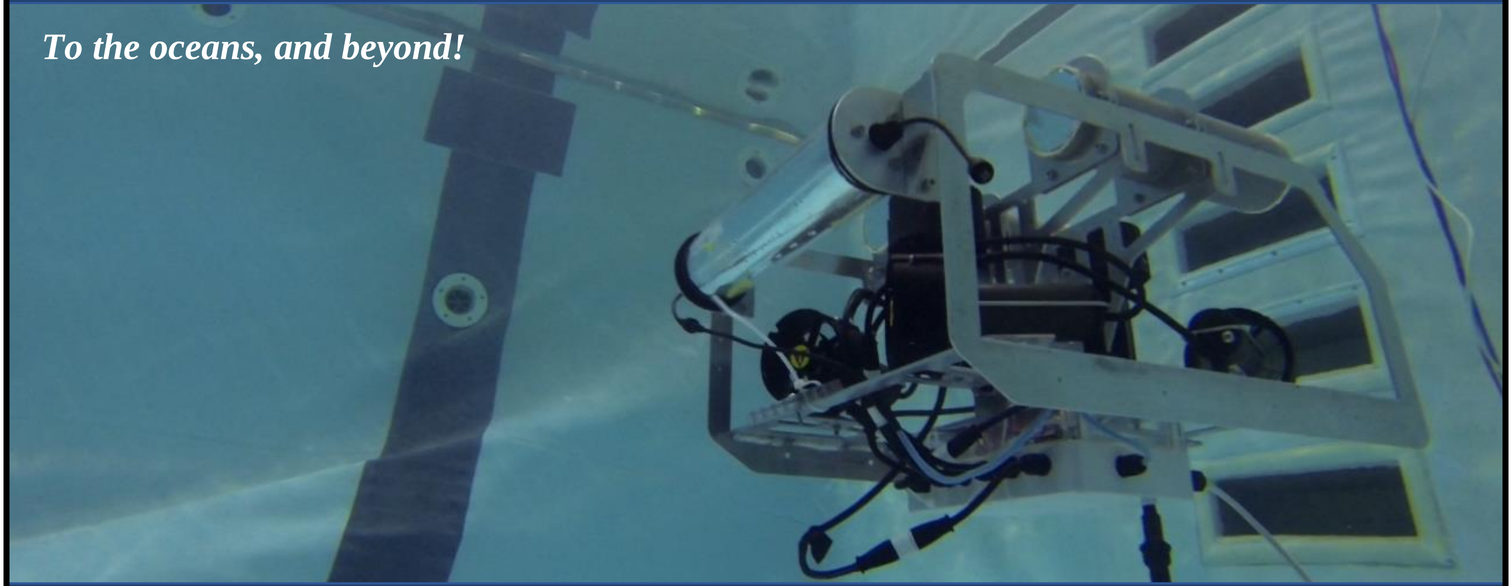
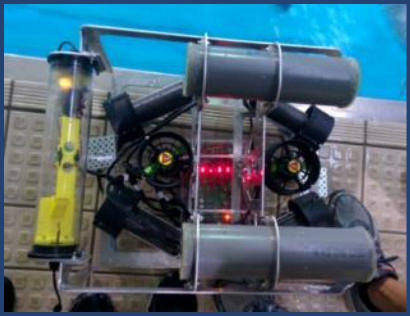
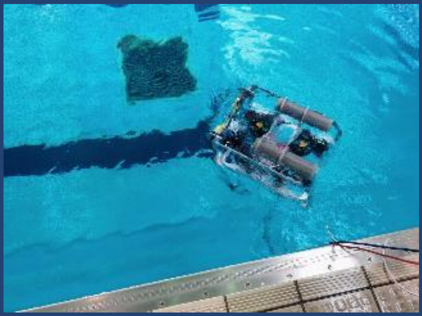

To the oceans, and beyond!

tigersharks co.

Taipei American School **Taipei, Taiwan R.O.C.**





<u>Team Members</u>

Anthony Lin: Chief Executive Officer
Gregory Huang: Chief Executive Officer
Mark Chua: Chief Financial Officer
Edmund Tong: Chief Operations Officer
XiaoYang Kao: Chief Technology Officer
Jin Suh Park: Chief Mechanical Engineer
Joey Brebeck: Robot Operator Specialist
Trisha Sinha: Financial Specialist
Valerie Lin: Documentation Specialist
Kevin Lin: Regulatory Officer
Emily Sun: Integration Officer
Tiffany Chiang: Engineer

<u>Mentor</u>

Rafael Garcia

Table of Contents

Abstract

As the recipient of the Design Elegance Award at the 2013 ROV MATE Competition last year, Tigersharks Co. is prepared and confident to build upon the experiences from previous years. This year, Tigersharks Co. will explore shipwrecks and uncover the mysteries inside them. First, Tigersharks will scan and document the ship and retrieve a ceramic dinner plate to determine the ship's home port. The Mk-V will collect physical samples such as microbes and determine the conductivity of groundwater. The vehicle will collect a sample of the microbial mat and recover and deploy a sensor. Finally, the Mk-V will remove the debris scattered around the shipwreck site.

Tigersharks Co. has constructed a custom-made ROV to accomplish these tasks. With a new plasma cut aluminum frame designed to house the components of the ROV, the frame is now lighter and more maneuverable by Seabotix thrusters. The Mk-V is also equipped with a pneumatic manipulator designed for collecting physical samples and ceramic dinner plates. The Mk-V is controlled by a custom 3D-printed and acrylic control box with custom PCBs.

The following technical report details the functions and features of the Mk-V and presents the vehicle systems, design rationale and design processes for each component. This report also elaborates on the safety guidelines, troubleshooting techniques, and improvements that can be made. Finally, it includes a financial report detailing the price and quantity of the components used for the vehicle, team member reflections, and acknowledgements to the individuals and organizations that have generously helped us succeed.

Founder's Remarks

Back in 2009, I founded the Tigersharks Company with a passion for marine exploration and a vision of creating efficient and affordable underwater ROV for the world. The company faced many obstacles in its first year - we lacked funding and the technological know-how in many aspects of the ROV. I was very fortunate to have Alex, Kevin, Justin, Derek, Gaga, and Hanpin in helping me to steer the company through its fledgling first year.

It feels unreal to see how much the company has grown in the past 3 years. With sufficient funding and innovative recruits, the company has become an industry leader in design and manufacture of underwater ROV. I am glad to see that the current CEOs, Anthony Lin and Gregory Huang, have taken the company in the right direction towards success and continual improvement.

I believe that my vision will continue to be fulfilled by those who share my passion, and I am very grateful for the tremendous amount of effort that everyone has put in for the company and the underwater ROV industry.

Lawrence Chang

CEOs' Remarks

Five years ago, we started off in a small storage room with limited tools; today, we have a fully equipped robotics lab with tools and machines that we have never dreamed of when we took our first wobbly steps. With new equipment available such as the welder and plasma cutter, the Tigersharks ROV Company celebrates its 5th anniversary with innovative approaches and superior manufacturing capabilities to construct the most advanced ROV yet.

Designed from the ground-up with CAD software and carefully fabricated through a laser cutter, 3D printer, plasma cutter, and a welding station, the company allowed itself to push for more intricate structures for our ROV. The team continues to demonstrate brilliant teamwork that resulted in the best looking and most robust ROV Tigersharks Co. has ever built.

As Co-CEOs of the company, we are both honored and delighted to present to you the culmination of research and development over the past year, our 5th Generation ROV - The Mk-V.

Anthony Lin & Gregory Huang

Theme and Mission Overview

In the 2014 MATE ROV Underwater Robotics Competition, Tigersharks Co. will employ a custom-made ROV, the Mk-V. It will accomplish various tasks involving shipwreck exploration and documentation[1], contribution to science, as well as conservation efforts. Mk-V will be deployed in "Shipwreck Alley", an area in the Thunder Bay National Marine Sanctuary replete with archaeological sites. This year, Tigersharks Co. is excited and prepared to answer to a Request For Proposals by scientists and conservation groups aimed to better understand the conditions that surround these sites.

To begin with, the ROV will survey the shipwreck with its cameras at three target locations, searching for clues that may identify the ship. Using lasers, the Mk-V will measure the dimensions of the ship. After thoroughly observing the shipwreck and identifying the cargo on the ship, the Mk-V will enter the shipwreck. The Mk-V will then enter the shipwreck and retrieve a ceramic dinner plate to the surface with the manipulator. After the shipwreck is successfully identified, the Mk-V will be equipped with a conductivity sensor and measure the conductivity of water. The Mk-V will then attempt to estimate the number of invasive zebra mussels [2]that are populating the shipwreck. The Mk-V will surface for company

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[1] Yoerger 152-161

[2] Fahnenstiel 435-448

personnel to attach the agar suction device to the ROV to the dual purpose magnetic collector (DPMC). The DPMC picks up the pipe as well as serves as a docking mount for accessories such as the agar suction device. Continuing on the theme of scientific endeavor, the Mk-V will collect a sample of a microbial mat[3], simulated by plastic cups of agar. After using the agar extraction device to collect the sample, the ROV will return the sample to the surface where the agar extraction device is detached from the ROV. Finally, the Mk-V will use the manipulator to pick up the plastic and glass bottles, as well as the anchor line and returning each of these items to the surface to complete the mission.

Design Rationale: Frame and Propulsion

Figure 1: Fully assembled ROV

Design description:

This year marks a significant leap in the company's ROV frame design. In previous years, the frame was designed around the materials (e.g. PVC pipes, aluminum channels) due to the lack of manufacturing availability. This year, with the extensive usage of CAD (computer aided design) and the purchase of the plasma cutter, Tigersharks Co. was able to design and build a frame customized to fit the components of the ROV rather than having to alter components to fit the frame.

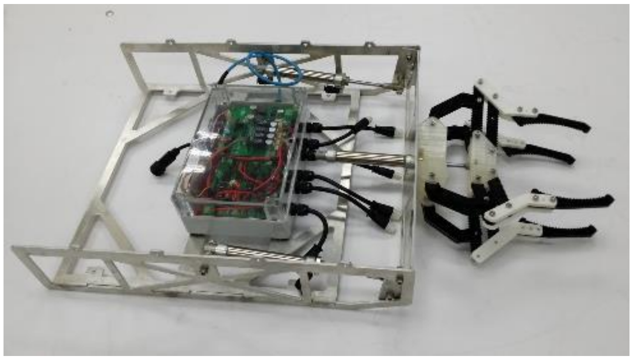

Figure 2: Assembled bottom half of ROV

Design rationale:

The usage of fabricated aluminum plates customized by CAD software allowed us to build an accurate base. The base is built out of aluminum plates which provides a compact mounting solution for the thrusters and reduces the fluid drag on the ROV. The interconnected design of the plates guarantees not only a robust structure, but also a sustainable base which can be used for future missions. The double decker base was built for this purpose as the bottom base containing mission props can be interchanged depending on the mission.

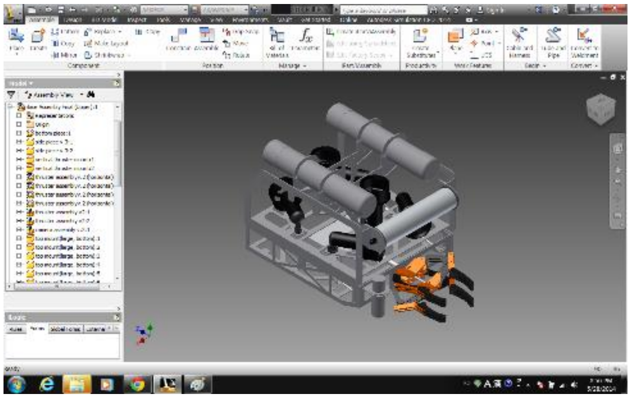

Figure 3: CAD model of the ROV assembly

Due to this year mission, the general layout of the frame was designed to satisfy the demand of stability and accuracy. The buoyancy tanks are situated on the top of the frame while the horizontal thrusters are placed on the bottom; therefore, the center of mass is concentrated in the lower part of the frame. When placed in water,

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[3] Marais 93-96

the ROV is ensured a stable movement in all axes. For the four horizontal thrusters, the thrusters aligned in a holonomic drive allows the ROV to move in any direction, independent of rotation. A holonomic drive is useful in situations that require for higher mobility and less traction than a standard drive system. It able to cater to the pilot's preferences, requiring less thought to adjust to the various conditions during a mission.

Variable Buoyancy Tank

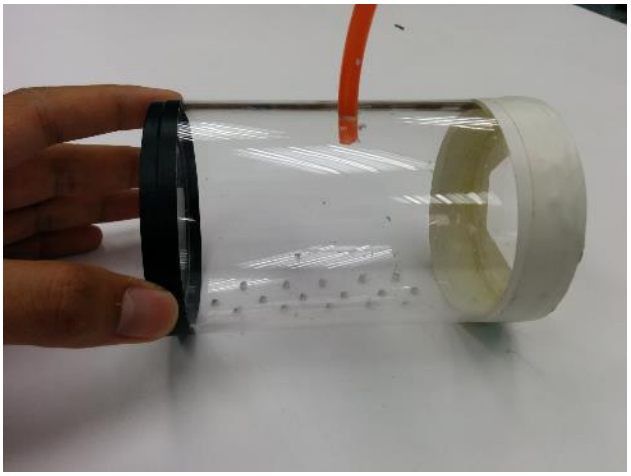

Figure 4: Prototype variable buoyancy tank

Design Description:

The variable buoyancy tank consists of an acrylic tube with an air tube leading to the surface and is open to the water. The ROV will be neutrally buoyant when the variable buoyancy tank is completely filled[4]. When resurfacing or carrying a heavy object, air is pumped into the tube to increase the ROV's buoyancy[5].

Design Rationale:

Surfacing has always been a time consuming process. To accelerate this process, we designed a variable buoyancy tank to decrease the amount of time it takes for the ROV to surface. Another problem was that when we were carrying mission items, the ROV would constantly be sinking with barely enough thrust to move up. To keep everything simple, we decided that the tank would be controlled manually with an on off switch with the ROV being neutrally buoyant when the tube is completely filled. We used transparent acrylic to help with the troubleshooting process in the design stages. It also provides visual feedback when the ROV is topside on the amount of water inside the tube.

Control System (Surface Control Box):

Figure 5: On-shore/surface control box

Design Description:

The onshore control system is used to translate human input from the PS4 controller into commands that the ROV can understand. In addition to sending commands to the ROV, the on shore control system constantly monitors diagnostics packets sent from the ROV as well as current usage. There is a Serial LCD that is used to display diagnostic information such as error codes, current, and voltage. The display greatly simplifies the debugging process of errors on the ROV. A current sensor is placed in the box to monitor current usage and allows the driver team to monitor any fluctuations in current usage. The current sensor (ACS711) also contains a protection circuit which cuts the circuit when the current exceeds the maximum current allowed

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[4] Zanoli 453-459

[5] Tangiarala 762-771

(25A.) There are two polarity controlled Speakon ports for power input and power output. On the back of the box there are two RJ45 jacks for communication with the ROV. On the right side, there are RCA ports for video signals.

Design Rationale:


Figure 6: Onshore control system internals

One of the most significant changes to the onshore control system is the use of a wireless controller. Previous years there has always been issue with cable management as well as insufficient cable length. Using the PS4 controller, the operator is able to freely move about during piloting operations. Some other changes is a reverse polarity protection system to further protect the control system in case of operator error. The reverse polarity protector consist of a P-Channel MOSFET which provides an effective protection system with minimal power loss.

Furthermore, this year is the first year we switched from the AVR microcontrollers to ARM. The reason being is additional processing power as well as extra UART (Hardware serial) lines. Last year we ran into the problem of having too little serial ports. Using the ARM chip (teensy 3.0) we can continue to use the Arduino development environment while having multiple serial lines for the display, communication for ROV, and debugging.

There is also a 3A 5V switching regulator to provide an efficient DC-DC converter to minimize heat production. This year we also utilized the RS485 communication protocol which utilizes differentials to increase reliability and speed of communication.

Control System (Below shore/Underwater Control Box):

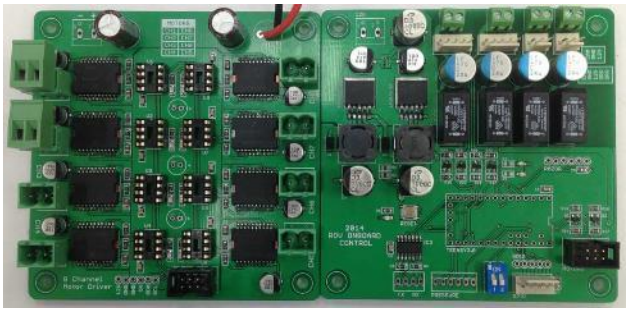


Figure 7: Below shore control box

Design Description:

The underwater control system is used to control sensors, motors, and cameras on the ROV itself. It receives commands from the onshore control joystick and controls the various systems accordingly. The underwater control system also has an Inertial Measurement Unit (IMU) that gives positional data of the ROV vessel, which allows axis-locking in the yaw axis. This gives high precision control when visually doing missions.

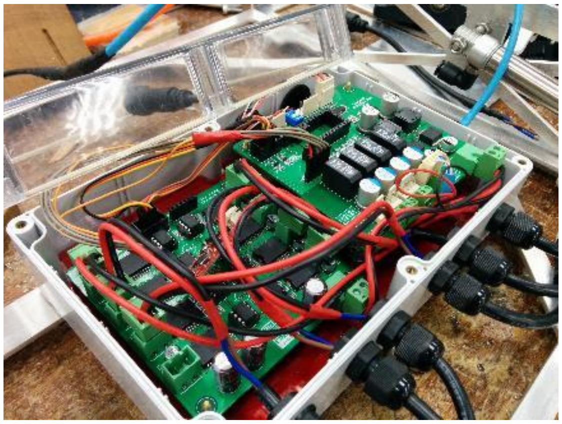


Figure 8: Onboard control system

Design Rationale:

We had significant problems with the camera signal dropping in our ROV MK-IV last year. After testing, we determined there is 300 Vpp of noise on the 12V when the thrusters were engaged, which is way too much for the sensitive camera modules. To fix this problem, each of the four cameras onboard gets its own 1A LC filter to smooth out any ripples on the 12V line. Our tether has also been converted to a single CAT5 cable. Two pairs are used for the two cameras, and third pair is used for RS485 communications. Each camera also has a balun to convert the 75 ohm video signal to 100. This ensures the signal stays strong after 20 meters of 100 ohm-impedance CAT5. CAT5 was used to ensure signal integrity for both data and video. It is also easily replaceable and cheap, which is a significant advantage over TS-04.

Motors are controlled with 5A MC33886 motor drivers. Each one is individually PWM driven with attiny85s, which also report faults over the I2C bus.

Eight channels of motor control: the four vertical thrusters can be controlled individually (in addition to the forward ones), giving the machine roll and pitch control.

The primary processor was also upgraded from an ATmega2560 to an ARM Teensy 3.0, which has a Cortex M4 processor.

Since there is significantly more processing to do for the IMUs, fault reporting, driving servos and other tasks, the upgrade gives much more flexibility.

Another problem with TS-04 were the unreliable SEACON connectors. We have exceeded the maximum number of reinsertions for the SEACON connectors, so electrical connectivity was spotty. This year we went with a cable-gland solution, which is much cheaper and replaceable. However, this means there are inline connectors hanging off the box, but we decided that it was worth sacrificing portability for availability and cost.

Software Flow Design

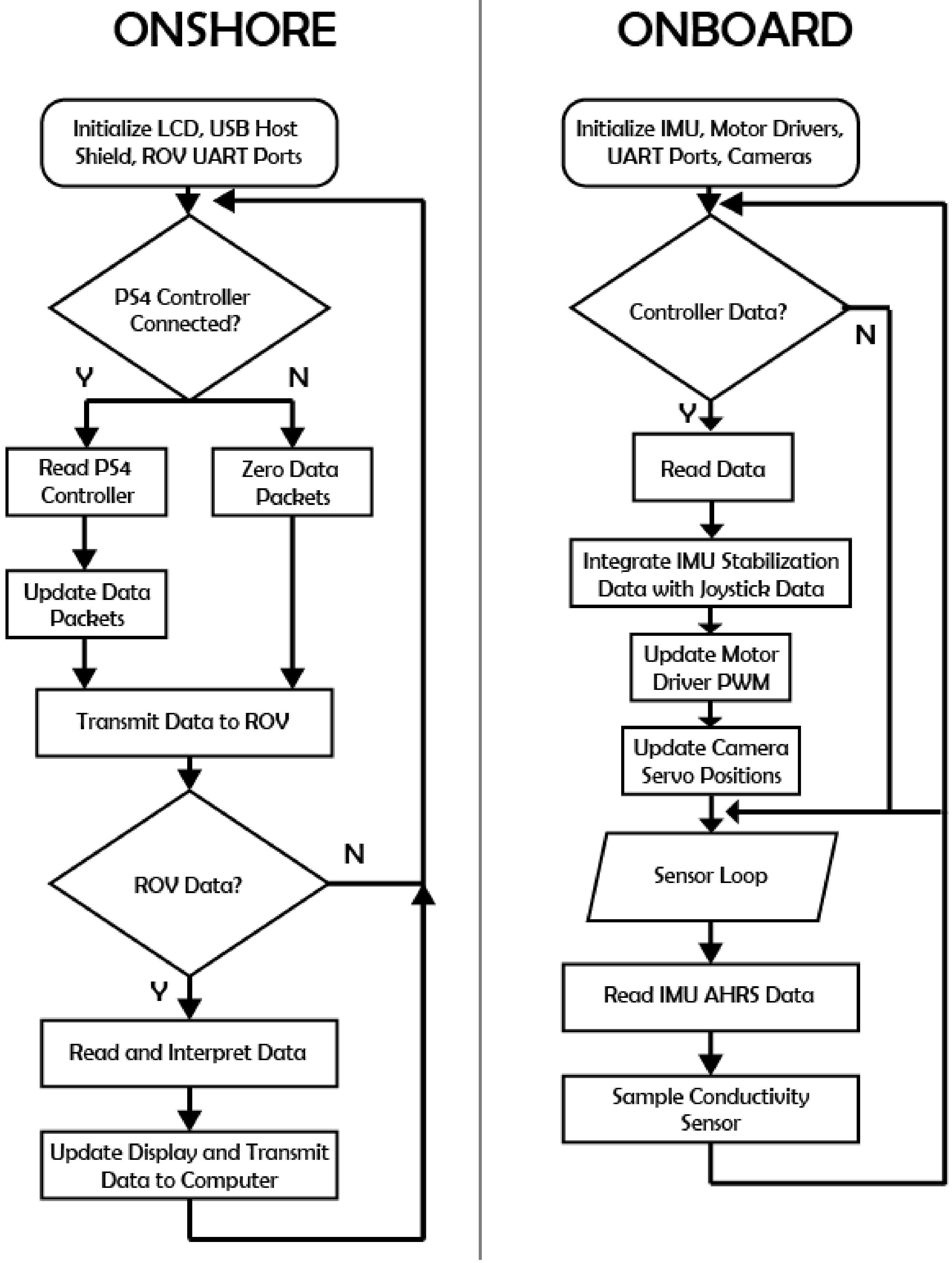
The onshore control system is designed with safety precautions and features to ensure the success of the mission. The processor retrieves data from the USB Host Shield and translates the data from the PS4 controller into motor packets that is relayed to the onboard control system. To ensure that the microcontroller is not overloaded, functions like querying the controller and transmitting data run in 10-100 millisecond intervals. In addition, the software system contains no while loops to ensure that there are no random lockups or freezes during operation.

To ensure the safety of the operator, when the PS4 controller disconnects or the ROV stops responding to commands, the onshore control system constantly sends blank commands that stop all motors from running.

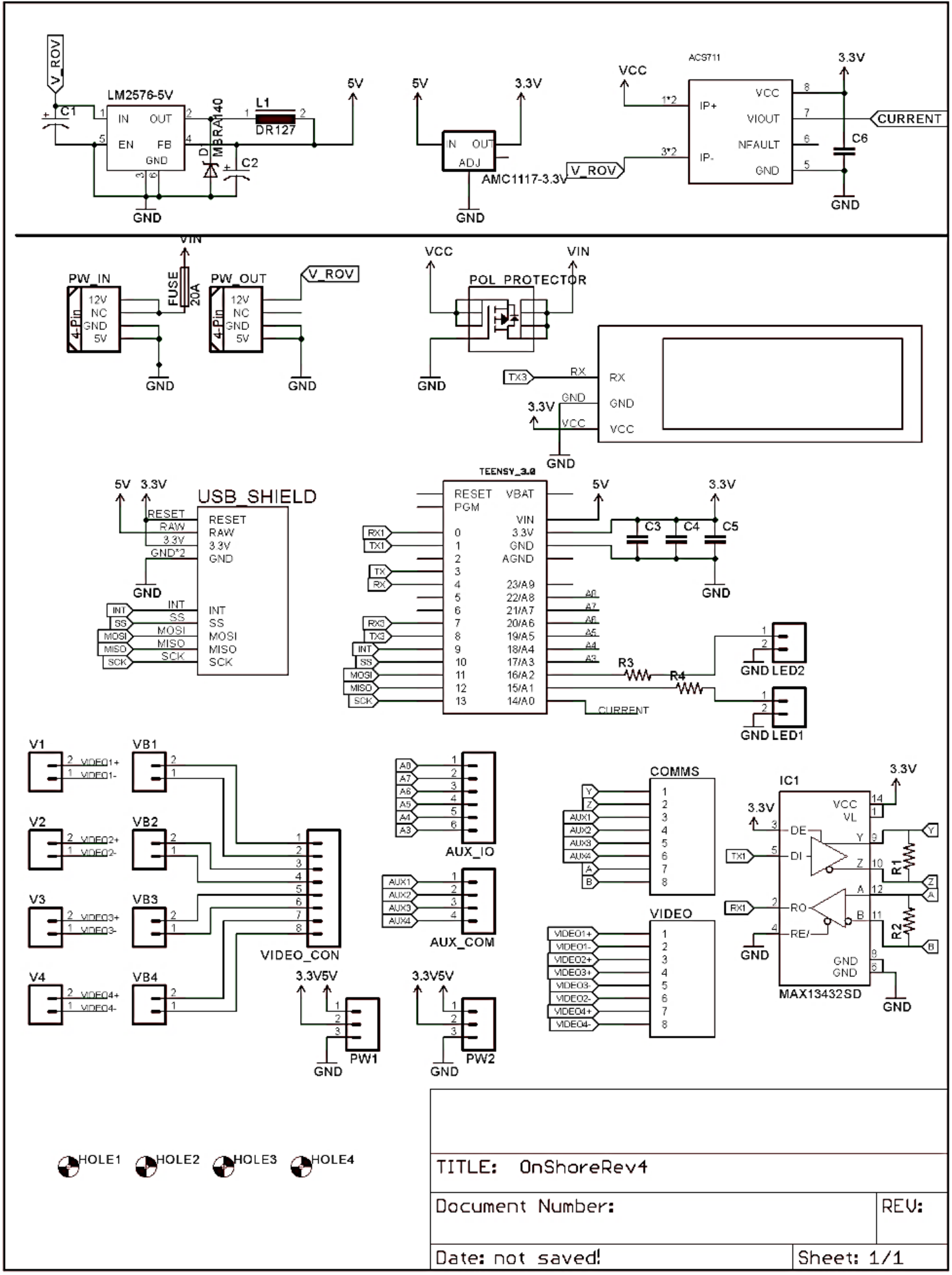
The onboard control system consists of two different subsystems that work together to carry out missions, and each of these have separate code running. The primary processor handles everything except driving motors and a bank of smaller processors handle motor driving. The code running on the motor controllers is simple- since the primary processor communicates with them through I2C, it simply waits for a request or transmission from the host and then sends out the appropriate motor PWM value to the h-bridge IC. The controllers also returns over-temperature or short-circuit data if the host processor requests it.

The primary processor has several loops for different tasks running at the same time with timer-based interrupts. The motor loop runs at 100Hz and sends motor data to the controllers. Another PID loop is run continuously to run the IMU PID algorithm. Communication from the onshore joystick and the serial IMU is handled asynchronously as new data is received.

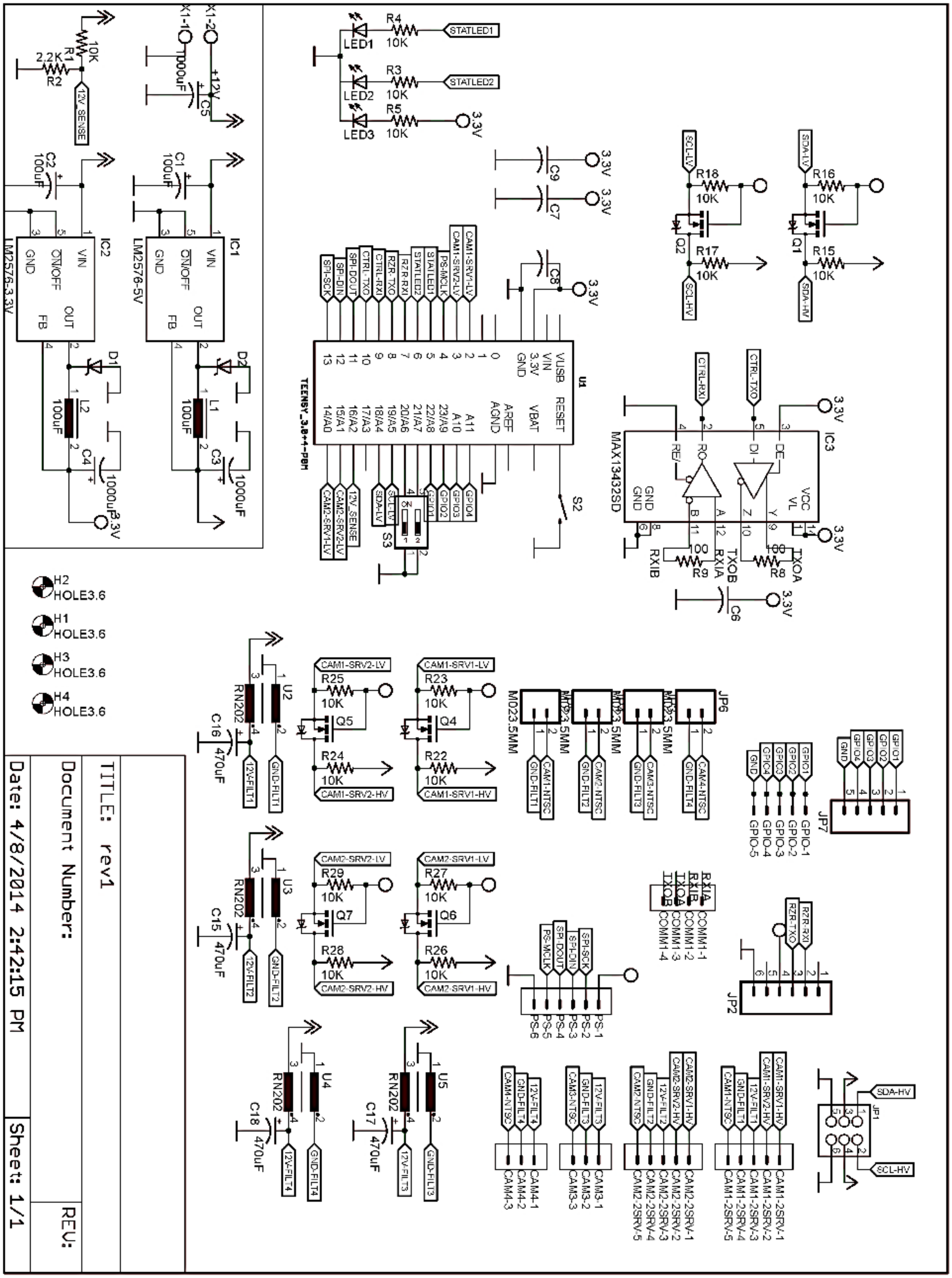
Software Flow Chart



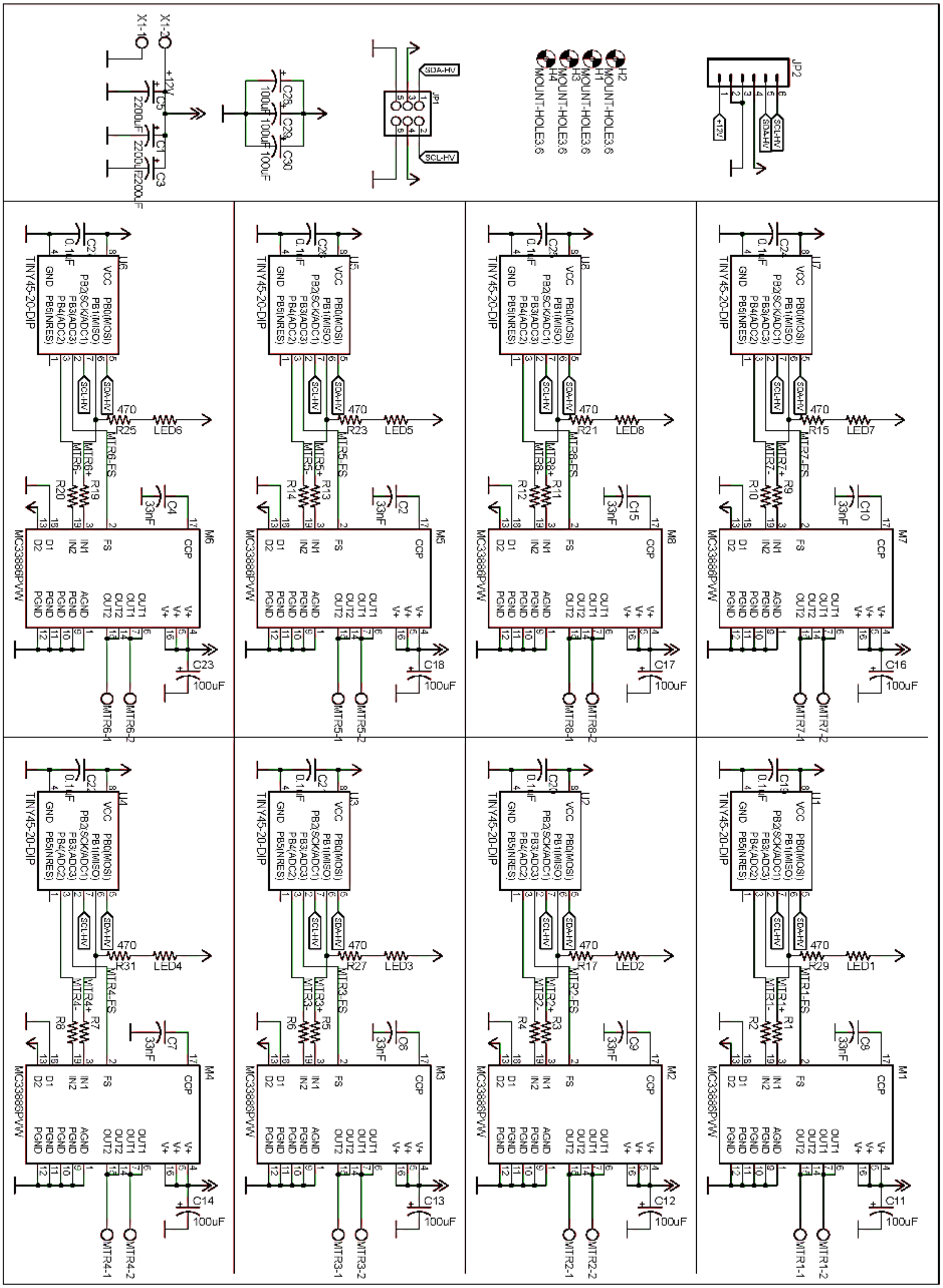
Electrical Schematic: Onshore Control System



Electrical Schematic: Onboard Control System (Main)



Electrical Schematic: Onboard Control System (Motor Carrier)



Tether

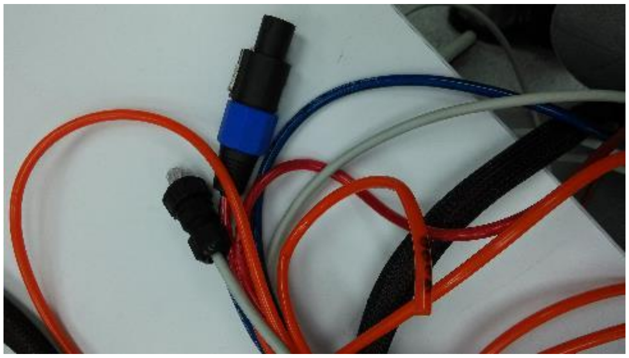


Figure 9: Tether cable with connectors

Design Description:

The tether remained quite similar to previous years, utilizing dedicated power lines and pneumatic tube to carry fluid power. However for communications, instead of using the six-core SEACON wire we used last year, we switched to ethernet cables for communication and video signals. The ethernet cable comprises of eight wires: four of them are used for cameras and four of them are used for communications to and from the ROV. In addition, rather than using cable ties to secure the wires into a tether, we are using a cable mesh. Pool noodles are also cable-tied onto the tether in order to ensure the neutral buoyancy of the tether since a previous problem encountered was the drag of the tether in any direction of movement as well as the weight of the tether that would pull the ROV down.

Figure 10: Tether with cable mesh

Design Rationale:

We decided to use cable mesh instead of cable ties to prevent potential hazards caused by cable ties. Cable mesh also protects the tether as well as improving tether handling. We eliminated the SEACON wires that were used because the use of the ethernet cable and power line could decrease the diameter of the tether and reduce the amount of pool noodles and foam that will need to be used in order to maintain neutral buoyancy. Also in the past two years, we have had a problem with the maximum reinsertion of SEA CON connectors thus we switched to RJ45 which has a higher number of insertion cycles.

Camera

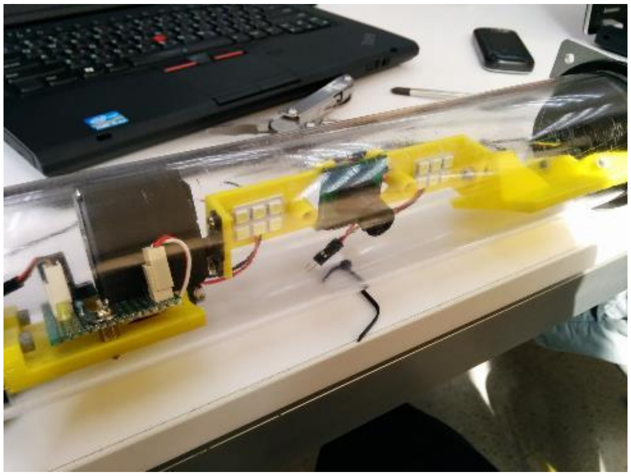


Figure 11: Front Camera

Design Description:

This year, our camera system experienced a complete overhaul. Instead of using PVC pipes and components to house the cameras, we now use transparent acrylic tubes with laser cut acrylic caps with a double O-Ring seal to provide a reliable and removable camera housing. Due to problems with insertion limits of SEACON connectors, we switched to a local supplier for waterproof connectors. There are two cameras this year for ROV, one wide angle single servo camera and one small auxiliary camera to supplement the main camera. Within the main camera, there are two parallel lasers for distance measurement as well as 2x 3 watt LEDs to provide lighting while navigating in the shipwreck.

Design Rationale:

A complete redesign of the camera modules was deemed necessary after thoroughly testing our previous camera modules. The decision was based on three predominating reasons: one, the modules were rather hard to maintain after being used for more than a year, two, the increased demand of current on the ROV destabilized and affected video quality, and three, after using the same design for the last three years, the modules had a 60% (3 out of 5 camera failures in the past 3 years) chance of failure due to leaks.

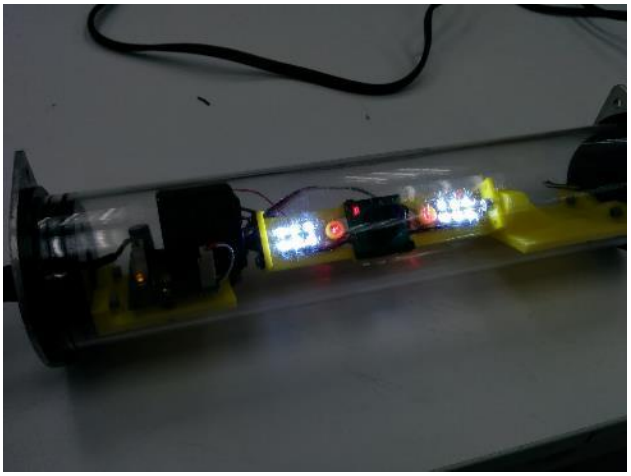


Figure 12: Testing LED and Lasers

From our five years of experience as a MATE ROV team, we have decided that only one camera was really necessary, the front facing drive camera. We have had years where all cameras leaked except the main one. Because of this, we decided to focus on creating one main camera that can be easily maintained and one that never leaks. Taking inspiration from a previous single servo camera, we lengthened the tube and changed the orientation such that we could point the camera up and down versus left and right. We also replaced the previous PVC screw on cap with laser cut acrylic end caps using a double O-Ring seal to ensure that no water would get through. The new end caps are more waterproof as well as more compact than the previous design.

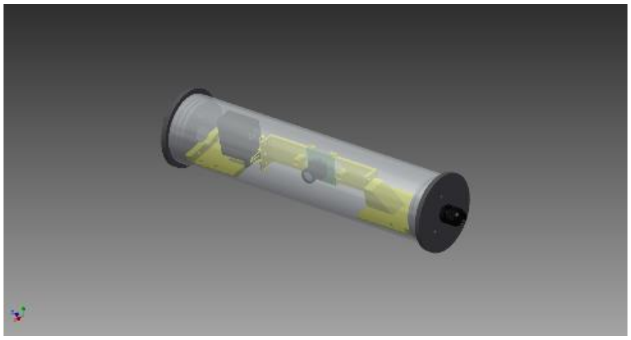


Figure 13: CAD model of main camera

With the housing done, all that was needed was to design the internals, how everything would fit together. Using CAD, a model was created of what the camera would look like inside. Inside the camera there would be a camera, a servo, lasers, LEDs, and a circuit board. The circuit board provided a way to hot swap components and generally improved maintenance operations.

Design Rationale: Mission Tasks

Mission Task:

Manipulator: Retrieve ceramic dinner plate and other non-ferrous objects such as glass bottle and anchor line to the surface.

Agar Extraction Device: Collect a sample of a microbial mat.

Dual Purpose Magnetic Collector: Acquire metallic samples from underwater environment as well as to house different sensors for the mission.

Conductivity Sensor: Measure the resistance between two solutions.

Prototyping:

Manipulator: We brainstormed two initial ideas to complete the mission tasks of the manipulator. First, there was a suction cup that could be attached to the surface of the ceramic dinner plate in order to retrieve it, however, we realized the impracticality of having a component that was only able to complete a single mission task. Thus, we designed a manipulator that could not only pick up the ceramic plate, but also other non-ferrous objects such as glass bottles and the anchor line and bring it to the surface.

Agar Extraction Device: Multiple options of extracting agar were visited through the designing process. First, a drill was suggested, but it was scrapped due to inconsistent sampling results, as well as the difficulty of removing agar from the ROV. Afterwards, a simple scooper was considered but also quickly scrapped. The suction device came about after prototyping with a PVC pipe and a PVC end cap attached and with a small hole drilled through the top. We figured that by holding down onto the hole after the pipe goes into the agar cup, the pipe can extract massive amounts of agar (nearly using all of the space in the pipe) and the agar stays in one piece after we let go of the hole. With this experiment we felt confident to use a water pump to extract agar.

Figure 14: Prototype agar extraction device

Measurement System: We initially brainstormed several ideas, in the end it was either a hardware approach or software approach. Two years ago, we prototyped a measurement system that consists of a motorized tape measurer. The problem with a hardware approach was that it was not consistent and required a lot of time to position the ROV into the correct position. Because of this, we decided to move forward with a software approach, using two lasers to generate a relationship between distance and pixels.

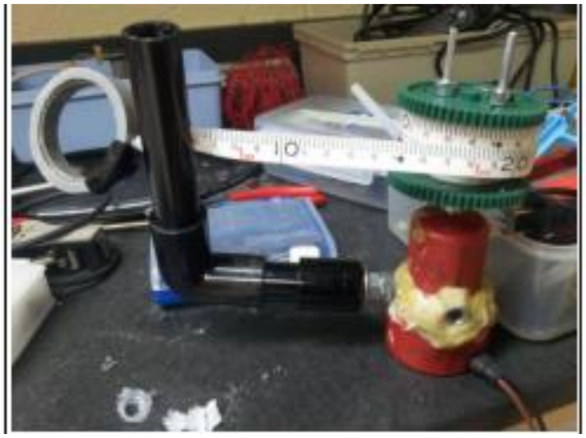


Figure 15: Prototype Measurement System

Manipulator

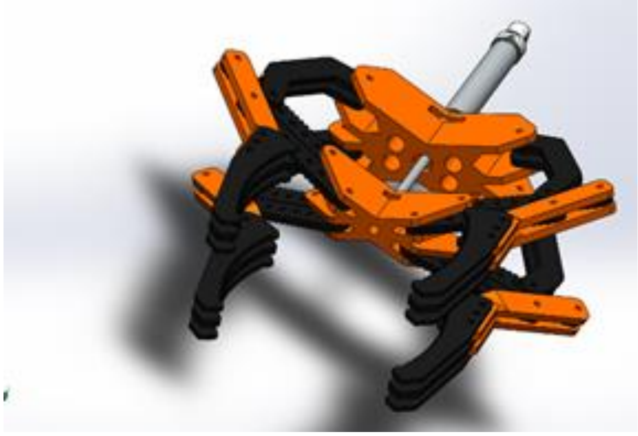


Figure 15: CAD rendering of manipulator

Design Description:

The manipulator employs a traditional four-bar linkage setup for linear actuation via a pneumatic piston. Each finger of the manipulator is offset at a 20 degree angle from the horizontal axis, and the manipulator gripper piece is angled back 20 degrees so that the gripper piece is parallel to the horizontal axis. The four bar segments are made of laser-cut acrylic, while the pneumatic cylinder four-bar linkage base attachment piece, piston head four-bar linkage attachment piece, and the 20 degree offset gripper pieces are composed of 3D-printed polylactic acid (PLA). Rubber gripper piece inserts sit between the acrylic gripper pieces for additional friction.

Figure 16: Open/Close state of manipulator

Design Rationale:

A four-bar linkage setup was chosen for its compatibility with the pneumatic piston. The acrylic and rubber gripper pieces have a rounded concave design to better fit around the assortment of PVC pipe items that need to be handled by the manipulator. The ceramic plate is manipulated using the vertical cavity created by the manipulator because of the 20 degree angle offset created by the pneumatic cylinder four-bar linkage base attachment piece. The four-bar linkage components and manipulator gripper piece are made of acrylic for durability and replaceability. The 100% fill solid 3D-printed PLA pieces also provide the structural integrity necessary for dealing with the stresses caused by the pneumatic piston.

The manipulator is actuated using a double-acting pneumatic cylinder to provide the force and speed required for efficiently gripping objects while retaining mechanical simplicity. Since the pneumatic cylinder does not contain any electrical components like a servo does, waterproofing a pneumatic cylinder is a much simpler task that results in superior reliability. Also, a pneumatic cylinder has the large range of motion which is useful for increasing the manipulator's area of effect.

The manipulator was designed using a CAD software called SolidWorks. Since the entire manipulator was designed using CAD software, features of the manipulator can be easily modified. After first making changes in the software, the changes can then be easily implemented physically by cutting or printing out a new piece. Thus, the manipulator is highly versatile and customizable.

Agar Extraction Device

Figure 16: Agar Extraction Device

Design description:

The suction device consists of three major components: The agar (microbial mat) container, the water pump assembly, and the magnetic mount. The agar container has space to contain roughly 250mL worth of agar. The water pump assembly contains a metal housing that was lathed and milled, a water pump, and two pneumatic pistons. The assembly connects to the agar container with a soft tube. Finally, the magnetic mount contains a neodymium magnet that connects to the DPMC (dual purpose magnetic collector), which then connects to the metal water pump housing.

Design rationale:

Since the agar sample is contained in a cup, extracting 200mL of it in one shot is not easy. We first considered a drilling mechanism that digs into the agar cup, but the volume of agar I get out of it varies significantly between trials. We ultimately went with the water pump design because it was by far the most consistent and efficient. The agar stays in the tube and slides out in one cylindrical piece (instead of a pile of chopped-up matter produced by the drilling mechanism).

We first bought a water pump from a local seller. Then, after measuring the dimensions of the pump, we designed a metal housing that houses the motor of the pump. Aluminum is used for both practical and aesthetical reasons - metal allows the motor to rest in a rigid and well-protected shell. After the housing was milled, two holes were drilled and tapped on opposite sides of the housing and two pneumatic pistons were attached to it.

After the water pump assembly was completed, we used CAD software to design the agar container - the cylinder that will penetrate the agar cup and retrieve the agar sample. We made a long cylinder, with one tapered end to help penetrate the agar, and the other end with a protruding pipe that allows the soft tube to connect the water pump's intake to the cylinder. Finally, we put two holes on opposite sides to mount the container onto the pneumatic cylinders.

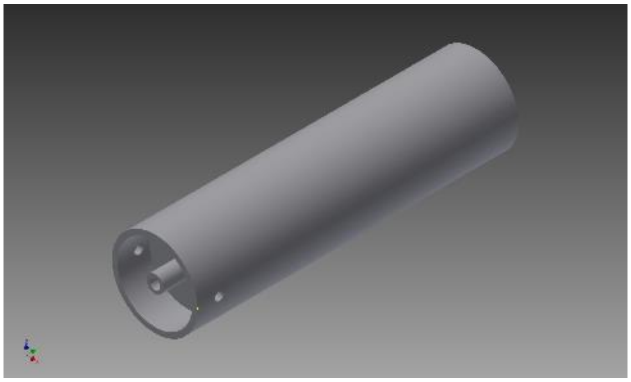


Figure 17: CAD model of agar container

The idea of screwing in two pneumatic pistons came from last years' experience. There was a camera module that protruded out of the bottom of the ROV and it was towed around at the floor of the pool multiple times throughout the missions. The repetitive hits led to a major leak that eventually destroyed the camera. With that vividly in mind, we wanted to make sure that everything rests within the ROV.

Conductivity Sensor

Figure 18: Prototype conductivity sensor

Design Description:

The sensor is responsible for measuring the relative conductivities of the two liquids. Two sharpened bolts are mounted on a nonconductive acrylic bracket. The resistance between the two is continuously sampled by the host processor, which allows us to determine if one liquid is more conductive than another.

Design Rationale:

The bolts are M5 bolts sharpened on the end. Bolts were selected because they are conductive and easy to mount to brackets. The ends were sharpened on a grinder so that the sensor can easily pierce the saran wrap over the cups.

Measurement System

Design Description:

The measurement system consists of two parallel lasers housed in the camera module with the lasers sandwiching the camera. By counting the pixels between the laser points on the camera feed, a scale is formed relating the pixels to distance. This allows us to apply the scale to number of pixels from one end of the shipwreck to the other end of the shipwreck.

Design Rationale:

A mechanical system was deemed too unreliable with moving. This year we decided to use a software approach with laser points providing us a scale to see how distances relates to the number of pixels.

Dual Purpose Magnetic Collector (DPMC)

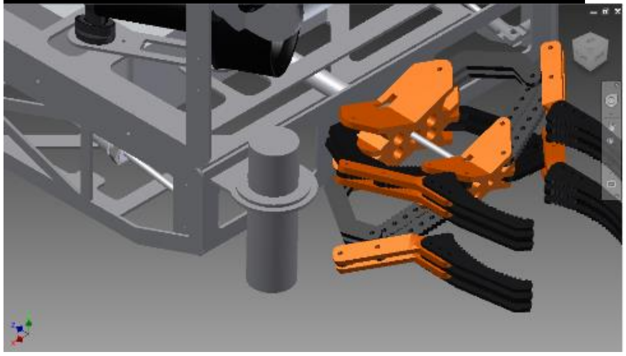


Figure 19: CAD model of DPMC on ROV

Design Description:

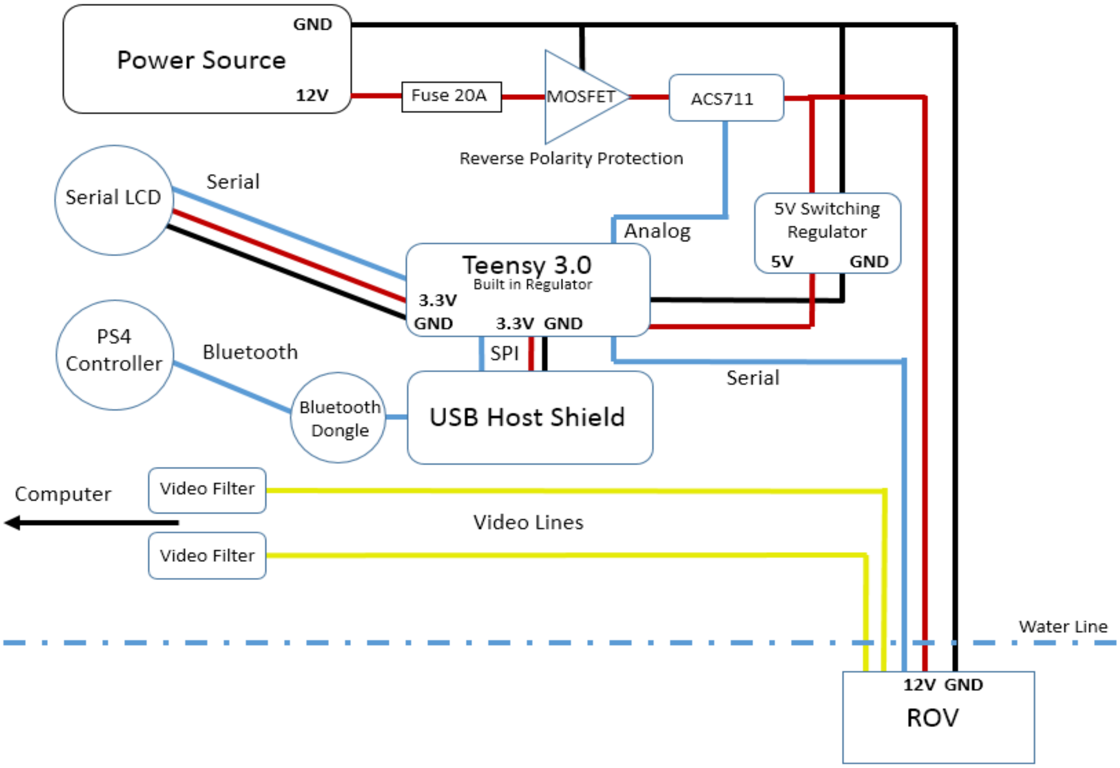
The DPMC is designed in a cylinder shape to house two 20mmx40mmx10mm Neodymium magnets with magnetic field strength of 0.4 tesla. It is assembled to the front plate of the ROV frame next to the mechanical manipulator.

Design Rationale:

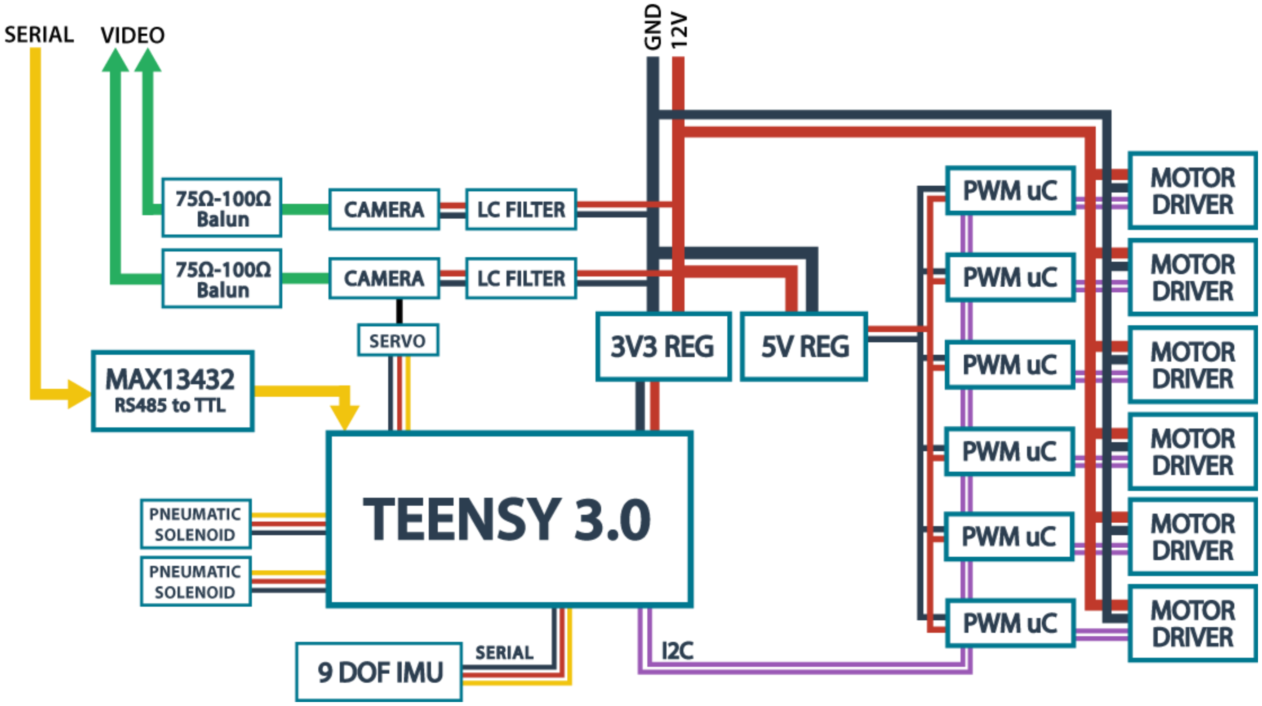
The purpose of the DPMC is to quickly acquire metallic samples from underwater environment as well as to house different sensors for the mission. When the lower end of Cylinder of the DPMC approaches the metallic sample, the neodymium magnets inside the cylinder attracts the sample thus is able to acquire with speed and less effort. The upper part of the cylinder can house both the Agar Extraction Device and the Conductivity Sensor. The magnetic portion of the DPMC attracts metallic parts of the sensors. This not only eliminates risk for attachments to become detached, but also allows different

System Integration Diagrams

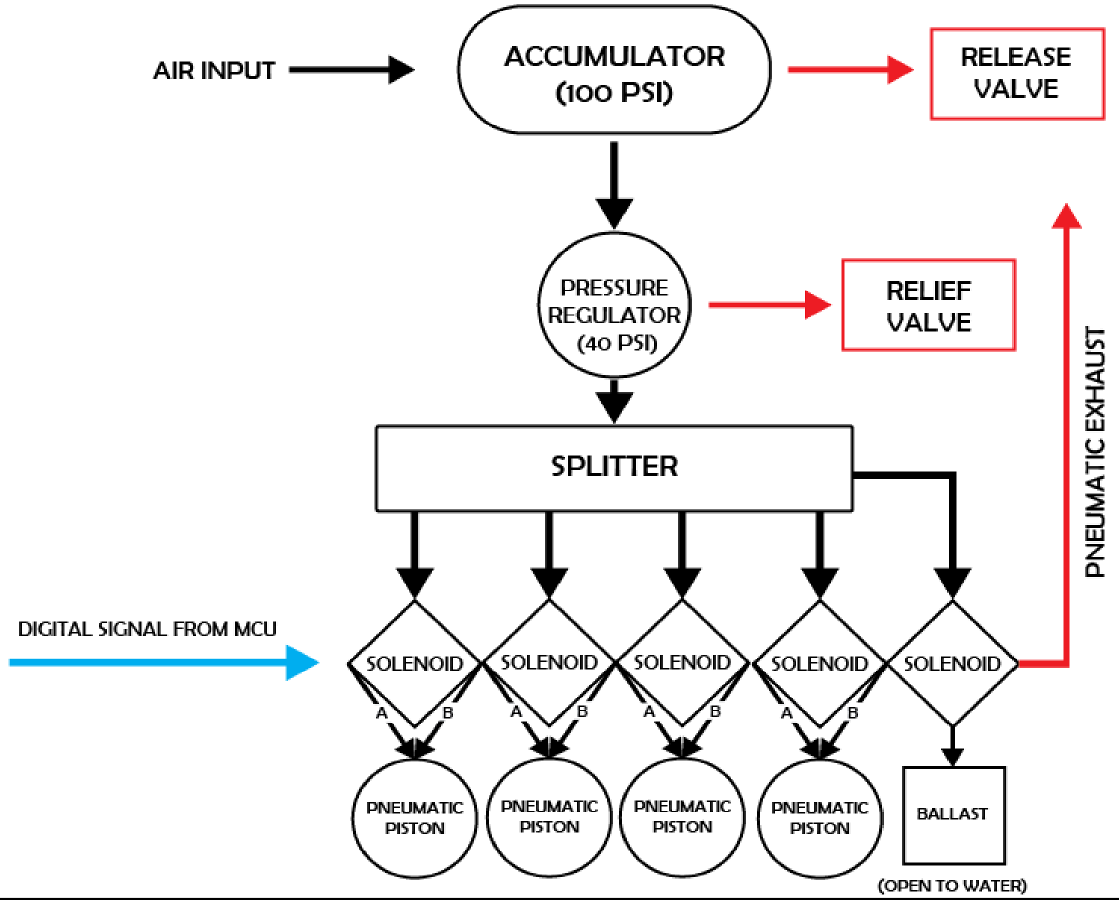
Onshore Control System



Onboard Control System



Pneumatic Power Diagram



Vehicle Systems

In Tigersharks, we strive to use as little commercial systems as possible. Almost every subsystem of the ROV has been meticulously designed and constructed to fulfill this year's task. The only thing that is commercial other than the base components such as IC's motors, and raw materials, are some waterproof boxes and connectors. These components needed to be bought because it was more cost effective to buy the materials such as the box and connectors.

Designing a lightweight, space efficient, and waterproof container for the control system has always caused quite a bit of issue due to the limitations in manufacturing. Without plastic injection molding techniques, creating custom houses proved difficult. This is why we decided to save the time it would take to research and design such a housing and use it on developing the control system, frame, manipulator, and additional peripherals.

This year, the only things reused from last year's ROV are the Seabotix motors. Due to the high cost of the motor, it was impractical to buy a whole new set of motors. However, each motor was still extensively tested to ensure that they were performing to specs. The motors were reused as the cost and time required to research and design water proof motors would be better spent on improving the claw and control system in order to ensure efficiency and competence in executing mission tasks.

The Mk-V will be powder coated with a waterproof seal. This is necessary to ensure the hydrophobic qualities of the the ROV frame, preventing rust and leakage. The powder coating is applied through external commercial services because we are unable to do so with the equipment in our lab.

Challenges

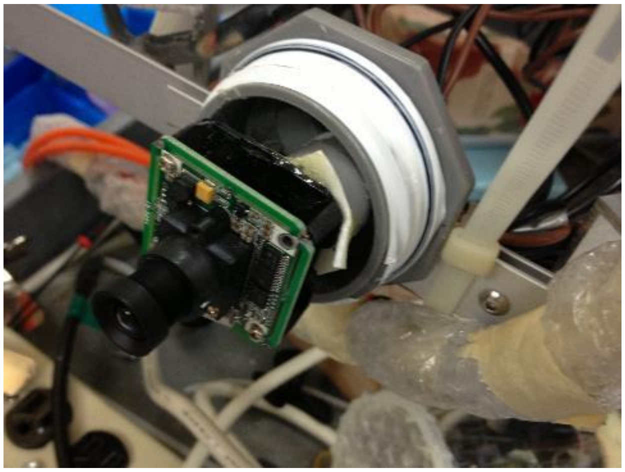


Figure 20: Teflon used for waterproofing camera system

Camera Quality:

Over the past few years, we have had problems with the stability and quality of the video signal from our cameras. There would constantly be interference created by a combination of factors such as 20 meters of the wrong impedance cable, higher current draw from the motors, and a non-isolated line for the signal ground. The method we used to overcome this challenge was that we implemented LC filters on the camera lines as well as baluns to ensure video quality over the CAT5 cable during high load.

Connectors:

Furthermore, another problem we faced was the unreliable Seacon connectors. We have exceeded the maximum number of reinsertions for the Seacon connectors, so electrical connectivity was spotty. To troubleshoot this problem, this year we went with a cable-gland solution, which is much cheaper and replaceable. However, this means that there are inline connectors hanging off the offshore control box, but we decided that it was worth sacrificing portability for availability and cost.

Communication:

Tigersharks personnel developed the interpersonal skills of accommodating each other's' schedules and compromising due to the large number of seniors that were in the team this year. By maintaining lines of open communication with each other in order to ensure that work was being done at every work session, we were able to be productive and complete all necessary parts on schedule. Team members were also aware of the correlation between their skillsets and the deadlines for the goals that needed to be achieved.

Troubleshooting

Various troubleshooting techniques were used to test the whole ROV vehicle in addition to specific components. For instance, the cameras on the Mk-V required extensive troubleshooting to prevent water leakages and improve visibility for the pilot. To improve water resistance, the cameras were housed in cylindrical clear cases with the sides closed with laser cut pieces of plastic. The cameras were placed in the sink first to troubleshoot for any water leakages. After component testing, the water leakages were fixed and the camera modules were tested with the entire vehicle. During this phase of the troubleshooting, the cameras had only minimal moisture in the casings which could be reduced by placing silica gel packets inside the casings to absorb the moisture.

After component testing, the whole ROV is tested in the pool to ensure full functionality of the ROV. The ROV is pressure tested and checked for leaks. Maneuverability and neutrality buoyancy is also tested. This year, only leaks were found and were easily solved by tightening components and adding additional O-rings.

Lessons Learned

With the addition of new members to the team each year, returning members of Tigersharks prepare tutorials to help develop fundamental skills in soldering, waterproofing, testing and safety. The technical skills developed in these tutorials are essential to building and designing to ROV. This year, the Mk-V was designed with extensive use of CAD software such as Autodesk and Solidworks. Many members learned various lessons in using CAD software for customized parts of the Mk-V.

Our manufacturing techniques have been greatly enhanced with the addition of various industrial grade power tools. CAD allows us to create high precision components using 3D printers, the plasma cutter, and laser cutter. The plasma cutters, in particular, were used extensively to cut aluminum for the frame with precision and improve the quality of our props. Custom made mounts for the camera, as well as components of the manipulator, were created using 3D printing. To minimize the weight of the ROV, the frame has been almost completely welded together. Welding provides great structural strength as well as a weight reduction from the lack of nuts and bolts. Tigersharks Co. is proud to announce to add welding as one of the new skills we learned.

Future Improvements

There are two main areas of future improvement that the Tigersharks Co. will aim to improve. First, Tigersharks Co. will improve the maneuverability of the ROV to maintain better pitch and roll control. A four motor vertical drive could be helpful to the maneuverability of the ROV, allowing us to complete the missions more efficiently. Improved pitch control will also allow us to have more stable camera captures. Another area that Tigersharks will improve in the future is the camera modules. In the past few years, the cameras have been problematic for our pilot and have made the some of the missions more difficult. The camera housing can be more transparent to give a clearer image for the pilot. In the future, Tigersharks Co. will purchase camera modules with better frame rate to provide better response time.

Safety

While efficiency and productivity are very important to Tigersharks Co., we value safety in the lab and in the pool even more. In the lab, safety goggles are always worn when using power tools, protective masks worn when welding, and tinted goggles worn when using the plasma cutter. Safety precautions are also taken for the handling of the ROV. All of the edges of the Mk-V frame were designed to be rounded so as to not pose a hazard to anyone picking up the ROV.

To ensure electrical safety, a current monitor that will highlight any discrepancies from normal operation is used. A reverse polarity protector consisting of a power transistor is used as well to ensure that no electrical equipment will be damaged by operator error. Furthermore, to prevent overheating caused by excess current, a fuse is implemented in the Mk-V's onshore control system. This will ensure the safety of all personnel and restrict the potential damage to nearby equipment and the ROV.

Before we began water tests this year, we revised the Standard Operating Procedure (Appendix A) so that we could not only maximize the productivity of our testing time, but also ensure the safety of all those on deck. When our vehicle is in operation in the water, we confirm that all swimmers are at least five meters away from the vehicle and take other typical pool precautionary measures such as ensuring that a lifeguard is present.

Reflections

Valerie Lin: As a first year ROV member, I had a lot to pick up and learn before I could get to work. ROV exposed me to various different skills and jobs as we work on the ROV; and being mainly in charge of the tech report, not only did I have to work on the mechanical constructions of the ROV, but I had to fully understand the processes and reflect back on the ideas and problem solving solutions we developed. I had to understand things conceptually and physically. Furthermore, ROV has taught me the importance of teamwork and communication. I had to communicate with all my team members to know where they were in the process. Although we were separated into departments, it didn't stop us from lending a helping hand to each other. Overall, I really enjoyed this year's eye-opening experience and I look forward to the competition in June!

Edmund Tong: As a second year member of Tigersharks Co., I have been able to expand my skills and learn even more this year. The team has been able to continue to use the advanced technological equipment that the TAS' Robotics Lab offers such as laser cutters as well as the new equipment such as the plasma cutter and welder in order to make the building process even more efficient. Additionally, as many of our members are seniors this year, I, along with the non-seniors in the team, have learnt to take up more responsibility and balance the tasks even better in order to make sure that we accomplish all tasks on time. In addition to balancing our schedules, my interpersonal skills have also been improved with our addition of new members that offer creative, new ideas that give us a new perspective on how to solve the mission tasks.

Kevin Lin: As a returner to the Tigersharks Co., I have had the opportunity to build upon the technical skills that I learned the previous year. It's truly been a privilege to have access to cutting-edge lab equipment such as the plasma cutter and milling machine. The advanced machinery has helped us immensely in the construction of the ROV, allowing Tigersharks Co. to create a tangible finished product out of our ideas. More importantly, returning to Tigersharks Co. has allowed me not only to build upon my skills, but upon relationships created last year and new ones this year. The mix of old and new members create an exciting experience with both institutional knowledge and a fresh working atmosphere. It is a great pleasure to work with Tigersharks Co.

Acknowledgements

We would like to thank:

- Dr. Hennessey, our superintendent, and Dr. Hartzell, our principal, for their financial funding and confidence in us. It is their support that allows Tigersharks to respond quickly to client's needs.
- Dr. Garcia, our mentor, for giving up his valuable weekend and holiday time for our work sessions and water tests. We would also like to thank him for his patience and guidance.
- Marine Advanced Technology Education Center, our competition organizers who have challenged us to create a greater product, and for providing this wonderful opportunity for us to compete with so many different teams across the world!
- The PTA, Friends of TAS, and donors of the Robotics Lab for giving us such a wonderful workspace and giving us access to high-tech equipment.
- The Taipei American School for allowing us to explore our passions and for letting us use its facilities!

References

Des Marais, DJ. "Microbial mats, stromatolites and the rise of oxygen in the Precambrian atmosphere." Glob Planet Change 97 (1991): 93-6. Print. PubMed PMID: 11538094

Fahnenstiel, Gary L., Lang, Gregory A., Nalepa, Thomas F., Johengen, Thomas H. "Effects of Zebra Mussel (Dreissena polymorpha) Colonization on Water Quality Parameters in Saginaw Bay, Lake Huron." Journal of Great Lakes Research 21.4 (1995): 435-448, ISSN 0380-1330, http://dx.doi.org/10.1016/S0380-1330(95)71057-7. (http://www.sciencedirect.com/science/article/pii/S0380133095710577)

Tangiarala, S., Dzielski, J. "A Variable Buoyancy Control System for a Large AUV." IEEE Journal of Oceanic Engineering 32.4 (2007): 762-771. Print.

Yoerger, Dana R., et al. "Autonomous and remotely operated vehicle technology for hydrothermal vent discovery, exploration, and sampling." Oceanography 20.1 (2007): 152-161. Print.

Zanoli, Silivia M., Conte, Giuseppe. "Remotely operated vehicle depth control." Control Engineering Practice 11.4 (2004): 453-459. Print.

Development Schedule

Mk-V Development Schedule

		Week																	
Project Manager	**Description**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Anthony, Gregory, Jin Suh, XiaoYang, Joey	Initial Design	🟨	🟨	🟨															
Anthony	Reusability Evaluation	🟦																	
Gregory, Trisha, Tiffany	Procure parts				🟨	🟨													
XiaoYang, Anthony	Contron System			🟦	🟦	🟦	🟦												
JinSuh	Frame design				🟨	🟨	🟨												
JinSuh	Frame construction							🟦											
Joey	Claw design				🟨	🟨	🟨												
Joey	Claw Construction							🟦	🟦										
JinSuh	Propulsion casing				🟨	🟨													
Anthony	Camera Design & Construction							🟦	🟦	🟦									
Gregory	Agar Suction Device								🟨	🟨									
Edmund, Gregory	System Integration									🟦	🟦	🟦							
Emily, Kevin, Xiao, Anthony, JinSuh	System Test											🟨							
Anthony, JinSuh, Xiao, Joey	Re-evaluation											🟦	🟦						
Joey	Claw Re-design												🟨						
Edmund, Gregory	Safety Guidelines are met												🟦	🟦					
Valerie Lin	Tech Report													🟨	🟨	🟨	🟨	🟨	
Anthony, Xiao, JinSuh	Revaluation, Final Design																	🟦	
Tigesharks team	Pack for Seattle																	🟨	🟨

Financial Report

Income					
Donations to TAS ROV Tigersharks		150000 NT*			
Expenditure					
Category	**Description**	**Price (NT)**	**Shipping (NT)**	**Total (NT)**	**Remarks**
Mission Props	PVC pipes	2772	0	2772	
	Copper wiring		0		Donated
	Pneumatic Tubing	2880	0	2880	
	Corrugated plastic sheet	820	0	820	
	Parts Box	130	0	130	
Mechanical	Aluminum sheets (plasma cutter)	7000		7000	Donated
	PVC (buoyancy tanks)		0		Reused
Electronic	Wires	136	0	136	
	Integrated circuit microcontroller	3518	298.15	3816.15	Reused
	ROV mainboard	2174.68	596.24	2770.92	Reused
					Reused
Claw	Pneumatic cylinders				Donated
	Acrylic				Donated
	ABS plastic (3D printing)				Donated
Servos	Servos				Reused
Camera	Cameras				Reused
	Metal sheets 3mm				Donated
	ABS plastic (mounts)				Donated
Propulsion	Seabotix Thrusters	90000		90000	
					Reused
Other supplies	Capacitors	124	0	124	
	Resistors	320	0	320	
	Acrylic (general use)				Donated
	ABS plastic (3D printing)				Donated
	Misc. hardware (heat shrinks, zip ties)	1914	0	1914	
Travel expenses	Air fare, ground transport, hotel (12 people)			69000	Paid by team members

*New Taiwan Dollar

Total cost w/o Donated/Reused: 99,096 NT
3,301.99 USD
Total cost: 105,682 NT
3517.69 USD
Account Balance: 44,318NT
1475.15 USD

Appendix

A: Standard Operating Procedure: Safety Checklist

R.O.V.S.O.P.

The Remotely Operated Vehicle Standard Operating Procedure (ROVSOP) is used as a checklist prior to every run. The purpose of the ROVSOP is to ensure the safety of all Tigersharks personnel.

Buoyancy System

	Visually and manually check for cracks, especially connections between acrylic and PVC before the ROV is placed in the water
	Manually check that the buoyancy system is firmly attached to the ROV

Cameras

Prior to System Plug-in:

	Check that all mounts are stable
	Examine if there are any cracks
	Double check the waterproofing connections
	Visually check for residual water or moisture in the camera cylinders

After System Plug-in:

	Check that the camera image orientation is correct
	Tightly seal the casing onto the module
	Make sure no wires are crushed together / caught in the threads of the casing

After Missions

	Check camera for leaks, identify the sources of leakage if there are any
	Clear the module by dumping the water out
	Wipe the module dry and let it sit outside to prevent corrosion
	Remove camera module from ROV and begin repairs.

Control System

	Ensure the waterproof box is sealed tightly
	Double check Seacon connections to box
	Ensure there are no visible shorts or disconnections in the on shore and below shore control system.
	Ensure that the correct plugs are plugged in and that they are not flipped
	Check if fuse is still working

	Test all motors and apparatus on the ROV
	Ensure there is proper communication occurring

Date: ________ **Completed:** __________ **Verified by:** _________________