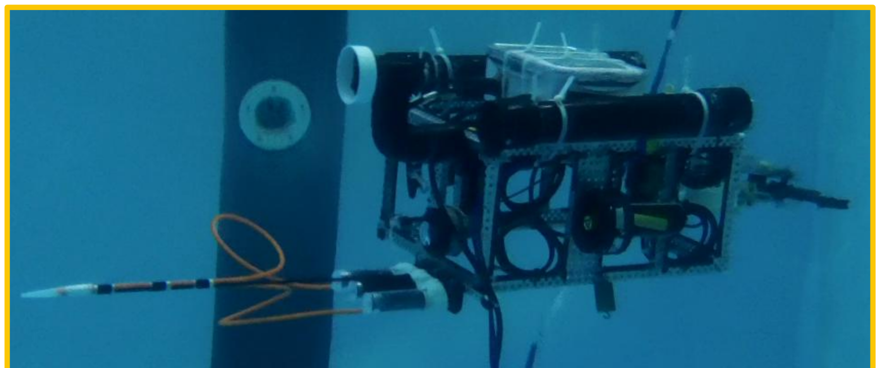
tigersharks co.

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



The TS-03 in action!

Team Members

Kevin Ku: Chief Executive Officer
Mandy Chow: Chief Financial Officer
Kateline Lin: Chief Operations Officer
Anthony Lin: Chief Technology Officer
Sarah Chang: Integration Officer
Arthur Chang: Regulatory Officer
Eric Lam: Mechanical Engineer
Jason Tong: Research & Development Engineer
Alvin Choi: System Engineer
Gregory Huang: Camera Engineer
Emily Huang: Testing Officer
Annette Wang: Regulatory Officer
Loren Weng: Pilot

Mentors:

John Simonton
Rafael Garcia

The TS-03

To the oceans, and beyond!

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Abstract

From last year's 12th place finish at the 2011 MATE ROV competition in just the second year of participation, Tigersharks is poised to build upon last year's success with new members aboard. Tigersharks has designed and built a remotely-operated vehicle capable of surveying the wreck site, determining the orientation and length of the wrecked ship, and examining the debris field, with the goal of creating a map of the wreck site. After removing a fallen mast and transplanting an endangered coral, the vehicle can confirm the presence of oil using two simulated sensors. Equipped with a suction device, the vehicle can remove oil from the fuel tank, reseal the hole, and return the sample to the surface.

The following technical report elaborates on the design rationale and the creation process of the vehicle's components, outlines troubleshooting techniques, challenges faced, and subsequent changes made, covers the financial aspects in a detailed budget report, includes a reflection from each member, with lessons learned and future improvements to be made, and concludes with acknowledgements to individuals and organizations who have assisted the team.

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 2 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 CEO, Kevin Ku, has 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

CEO's Remarks

I am truly blessed to have led a creative, dedicated, and passionate group this year as we continue to fulfill Lawrence's vision. I especially want to thank my chief officers, Mandy, Kateline, and Anthony in helping to lead this wonderful team.

It has been a truly amazing experience leading the team towards the creation of the TS-03 – the latest and most advanced ROV of the Tigersharks Company. Equipped with state of the art technology and innovative designs, the TS-03 is designed to efficiently handle the demanding task of surveying World War II era shipwrecks. Furthermore, TS-03 represents the culmination of the knowledge and experience that the company has gained over the past 2 years, making it a highly adaptable, efficient, and cost-effective ROV.

The Tigersharks Company aims to improve human lives with our ROV, and we strive to meet the needs of our global clients. The company will continue to grow and innovate in order to provide high quality design and service around the world.

Kevin Ku

Theme and Mission Overview

World War II was a historic human calamity in every conceivable way. Millions of lives were lost and cities were reduced to nothing but rubble. Off the coast, thousands of ships destroyed during the war sunk to the sea floor, and have remained there ever since. They pose significant risks that only intensify with continued neglect, for many of these vessels contain oil and other hazardous materials. Complications range from environmental to socioeconomic: habitat loss due to pollution leakage will threaten the survival of a myriad of marine species, endangering some and driving others to extinction, and seriously disrupt the global food web as a result. With less marine wildlife to depend on as a food source, the problem of world hunger will be significantly aggravated given the human population growth rate. Additionally, ocean contamination will preclude the possibility of marine tourism, and many countries with booming tourist industries will suffer a significant economic setback. Now is the time to start paying attention to these potentially dangerous vessels, one of which is the SS Gardner, an oil-bearing warship sunk by German U-boats during WWII. It lies off the coast of Florida, and has been identified by NOAA, the U.S. coast guard, and the U.S. Navy as a "high risk sunken vessel." It is our goal as the Tigersharks company to investigate the situation and hopefully eradicate similar problems in the future.

But before the company can delve into solving the problem, there are debates that need to be settled. First off, there are those who believe that these war sites are sacred and should be left undisturbed. They believe that such zones represent a piece of culture and history, and should only be explored at most. The company's belief, however, is that the future is more important than the past, and therefore, the risk must be attended to. After all, what good is it to save a piece of the past, just to have it endanger the future? However, the Tigersharks company would like to reach a compromise. First, Tigersharks proposes that only a select number of the most important vessels should be marked as cultural heritage sites out of the many thousand that lie on the sea floor. The rest should be destroyed as a safeguard for the future. Regarding the more important vessels, these areas should only be surveyed to begin with. If there is no leakage detected, then the shipwreck site will not be tampered with as to preserve its cultural value. The shipwreck should be reassessed every so often for dangers. If leakage is detected, the hazardous materials will need to be removed, hopefully with minimal impact on the vessel. The Tigersharks company hopes that other governments will join in on the mission, and that each will attend to the sunken vessels that once belonged to their country. If the vessels are not dealt with and environmental problems ensue, the country owning the vessels should be held responsible. Working together, we can keep our oceans clean!

In the 2012 MATE ROV Underwater Robotics Competition, Tigersharks will employ a custom-made ROV to explore the dangerous areas. First, the Tigersharks crew will survey the shipwreck site, which involves determining the length and orientation of the ship, scanning the ship with sonar, creating a map of the site, and identifying the surrounding debris as metal or non-metal. Second, the crew will proceed to remove the hazardous fuel oil from the vessel. Before any part of the actual task is attempted, however, the site will be cleared to minimize obstructions to the mission, and two endangered corals will also be carefully transplanted from the ship's hull. Then, using two simulated sensors, the crew will determine if any fuel oil still resides in the fuel tank, and if so, will extract it by penetrating through a layer of petroleum jelly. Finally, the hole will be resealed with a patch, and the sample returned to the surface for further examination.

Safety

At Tigersharks Co., safety is the number one priority, in both the workplace and the pool. As basic precautions for ensuring that the ROV is safe for manual handling, cut edges of zip ties are filed down and then covered with a layer of padding or tape. Surrounding Seacon wires coming out of the ROV control box are neatly bundled on the ROV frame, keeping them out of harm's way. Additionally, all the motors are enclosed to prevent damage to nearby wires or personnel, and are clearly marked with caution labels. As for the electrical components of the ROV, everything is carefully waterproofed with heat shrinks on the wires, silicon, and acetoxy, since live wires can be dangerous. Inside the ROV control box, a humidity sensor has been installed, which can measure the humidity of the air inside the box and help the team to check for leakage. A second sensor measures the temperature inside the same control box, to check for any overheating. Most importantly, there is a fuse on the onshore control system. In case the wiring becomes overheated due to excess current, the fuse will blow, which cuts off the power and, in turn, prevent any damage to the ROV or nearby equipment.

Troubleshooting Techniques

As a general design guideline to minimize technical errors, we as members of the Tigersharks company always draw and label our designs carefully. By doing so, we were able to plan in advance, predict and avoid challenges, and share the designs with other members of the team. Additionally, we tested the ROV in parts. Instead of completing the whole design, then finding out that one component did not work, and having to redo the entire design, we were able to change the overall design based on the requirements of the parts. For this reason, we made many components of the ROV removable. For instance, the arm, suction device, and cameras were made separately from the robot and later attached to the main frame with screws; the control box and buoyancy tanks were secured with removable zip-ties. This ensures maximum efficiency as components can be tested separately and simultaneously.

A trial and error method was used to troubleshoot for problems. For example, the method came in handy during the construction of the patch dispenser. The patch dispenser works by holding the handle of the patch in place with a series of crisscrossed rubber bands. On one hand, it must provide enough force to hold the handle of the patch in place, but not so much so that it is stronger than the Velcro and prevents the patch from being attached to the opening of the bucket. In this case, trial and error was faster and more practical than theoretical calculations in determining the required amount of tension.

Design Rationale: ROV Components

Frame and Structure

TS-03 with the aluminum VEX frame shown

Design Description:

The ROV frame is box-shaped with open sides, made out of aluminum VEX bars with holes in them, connected with screws and nuts. The auxiliary parts are attached to the frame with nuts and screws, putty, or zip ties.

Design Rationale:

Since the biggest problems with the ROV last year came from the lack of stability with the electrical system, the company's main focus was not with designing a new frame. Last year, a ROV frame made out of aluminum VEX bars was used, which effectively met the set goals of having flexibility, stability, and a manageable weight. The aluminum made the frame sturdy but light enough for easy maneuvering. The holes in the bars allowed for the auxiliary parts (arm, syringe system, etc.) to be easily attached and detached from the frame with screws and nuts, providing flexibility. Lastly, all the open spaces of the frame provided less surface area and thus created less drag in the water. The VEX parts, especially with the shipping fee, were expensive from the previous year. Since the frame worked so well last year, it was reused this year, which greatly cut back on costs.

Electrical Control System Overview

Our electrical control system is split into two sectors; an onshore sector and an underwater sector. The onshore sector is composed of a main control box that contains two Arduino chips. The main Arduino chip communicates with the PS2 controller through SPI (Serial Peripheral Interface) and communicates (in both directions) with a "super" Arduino chip underwater through serial. When the pilot uses the PS2 controller, the controller will send commands to the main Arduino chip onshore, which would then read the values, scale them, and send them down to the control system (containing the super Arduino chip) underwater. The super chip, in turn, will send the values to the motor drivers.

Onshore main control system (Arduino chips are contained within this box). The red plastic cover holds the on and off switch for the ROV.

Arduino "super" chip

The servo controller and LCD system are connected to an auxiliary chip in the onshore main control box. When the servo controller, consisting of 3 two way switches, is being utilized, the auxiliary chip will communicate with the main Arduino chip through I^2C, and the main Arduino chip will then send commands down to the super chip below. The super chip will then transmit the values to the servos on the arm or those attached to the cameras. The compass and sensors on board the ROV send signals to the super chip, which transports the information to the auxiliary Arduino through the main Arduino, and thus will appear on the LCD display. The LCD display also shows any errors. The camera signals connect directly to a video LCD through the Seacon.

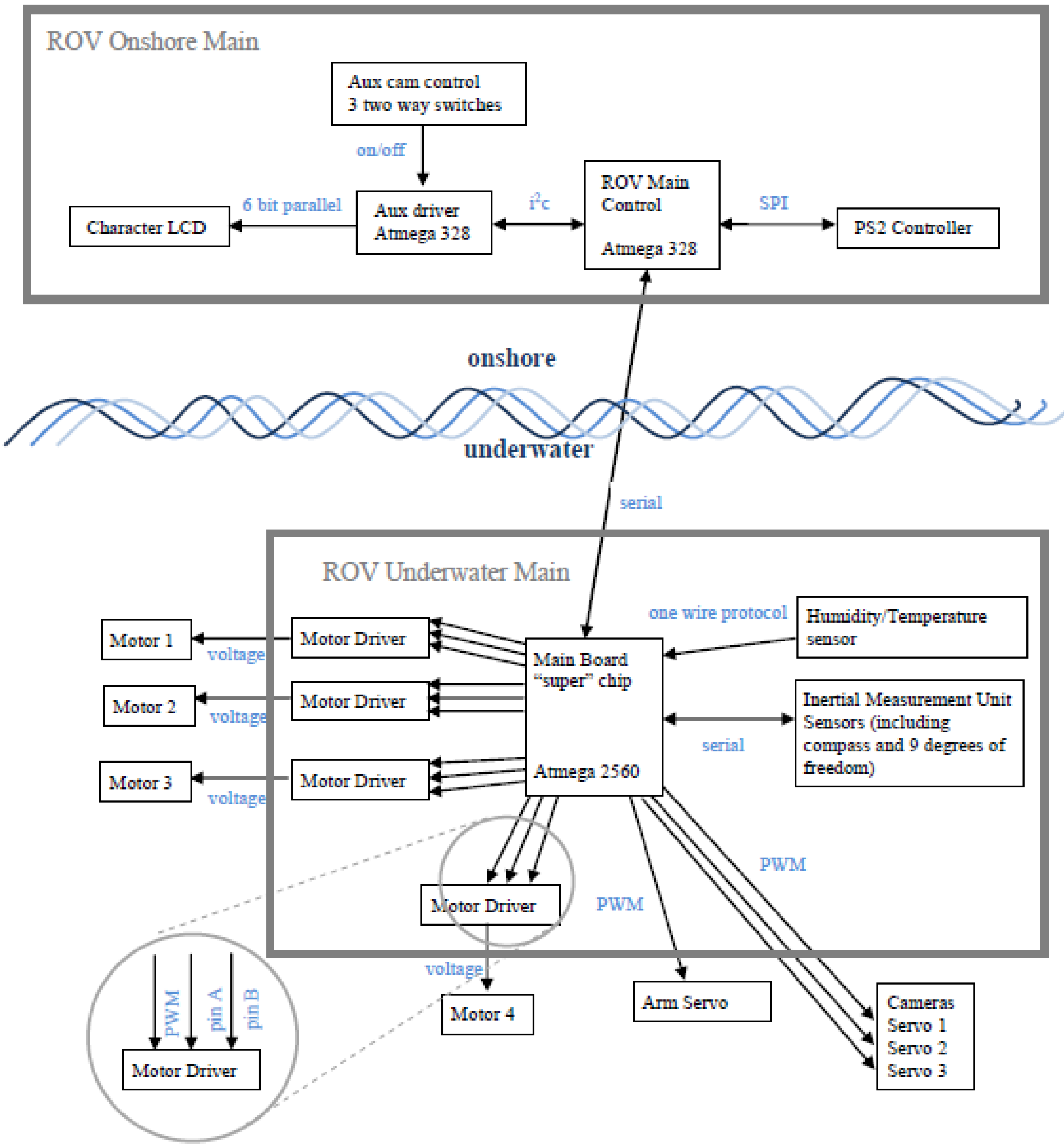
Three 2 way switches

LCD

Logic Table for Motor Driver Operation

	IN-A	IN-B
Brake to VCC (Regenerative Braking)	High	High
Clockwise Turn	High	Low
Counter Clockwise Turn	Low	High
Brake to GND (Coasting)	Low	Low

System Block Diagram



Servos

Similarly with the motors, the servos also communicate through PWM signals. However, the different duty cycles (how much it is turned on), determines the angle. Zero PWN is neutral.

Servo

Compass

Mission Task:

To determine the orientation of the shipwreck.

Design Description:

The compass contains three axes, the x, y, and z axes. It has 9 degrees of freedom, which is the number of ways it can move. An IMU (inertial measurement unit) board contains a gyroscopic (angular), an accelerometer (linear acceleration), and a magnetometer (magnetic fields that determine direction), each with three axes. All three of these sensors are fused together to make a tilt compensated compass. An additional Arduino chip within the compass interprets the values, and then send those values to the super chip through serial communication.

Design Rationale:

Originally, the plan for determining orientation was to have a camera zoomed in on a physical compass. However, this plan required adding another camera (which would complicate the control system) and was generally unreliable. Thus, the compass computer chip was used instead.

Motors

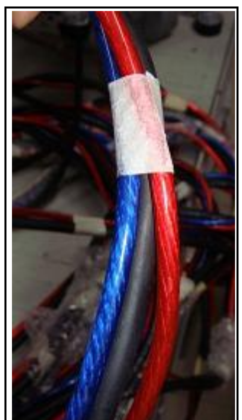
The motor modules are individual circuits separate from the super chip underwater. Each motor has a PWM (pulse-width modulation), which controls the motor speed. PWM essentially turns the motor on and off for a certain period of time within a few milliseconds. For example, if the motor is turned on for half a millisecond, then off for the next half millisecond, the motor runs at 50% of its speed. Besides the PWN, there are also two pins that control the directions. When the A pin is on, the motors will turn clockwise, and the ROV will move forward. When the B pin is on, the motors will turn counterclockwise, which will cause the ROV to move backwards.

Seabotix thruster

Tether

Design Description:

Three tethers connect the underwater control box to the onshore control box. One of the tethers (a Seacon) contains six wires: a Tx that transmits signals from the main onshore control box to the ROV control box, a Rx that transmits signals the other way, camera signal 1, camera signal 2, camera signal 3, and one wire that is unused. The other two tethers (speaker wires) are single lines responsible for power. One supplies 12V while the other is ground. The pneumatic tubing for the suction device is also attached with the tether for organizational purposes. Bubble wrap secured onto the tether makes the tether more neutrally buoyant and



The three tethers with different colors

prevents it from dragging the ROV down underwater.

Design Rationale:

One of the problems encountered last year was that the wires couldn't carry all the needed power because they were too thin. Therefore this year, the 12 volts and ground wires were changed from Seacon to thicker speaker wires.

Control Box

Design Description:

The control box is made out of three separate pieces of acrylic and contains a removable tray. It houses the ROV control system.

Design Rationale:

The company's main goal was to make the new control box easily repairable. A portable tray that holds the programmed chips was inserted inside the control box. The chips were then stacked onto each other, making them easier to fix if a problem is detected. Two rails made by vex parts helped secure the tray, and allowed it to slide in and out of the box more easily. The tray and rails were then placed into a smaller rectangular acrylic box (first part). Once done, the smaller box that contains the tray will be inserted into a larger acrylic box that has one of its sides unsealed. The four boxes would have 4 holes each that provide room for the Seacon.

Underwater control box
(Double layers of Lock and Lock boxes)

Then the Seacons were glued into place. O-rings were then placed on the open side of the larger box to help the separate piece seal tightly to the box, which would also prevent water from entering the control box. Then two seal caps were installed onto the large box which made sure that the plate seals tightly to the larger box.

Propulsion

Design Description:

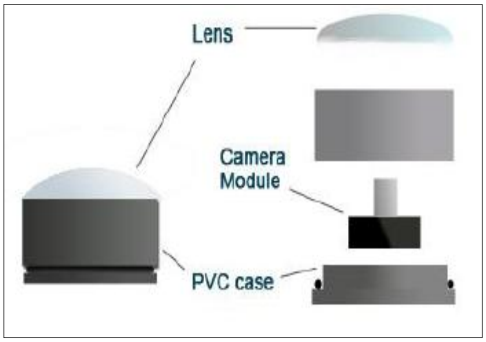
The motor modules are individual circuits separate from the super chip underwater. Each motor module uses PWM (pulse-width modulation) to control the motor speed. PWM essentially turns the motor on and off for a certain period of time within a few milliseconds. For example, if the motor is turned on for half a millisecond, then off for the next half millisecond, the motor runs at 50% of its speed. Besides the PWM, there are also two pins that control the directions. When the A pin is on, the motors will turn clockwise, and the ROV will move forward. When the B pin is on, the motors will turn counterclockwise, which will cause the ROV to move backwards. Already waterproofed Seabotix thrusters are used on the ROV, which have a propeller guide and are specifically designed for a ROV propulsion system.

Design Rationale:

Another alternative for the propulsion system would be to use bilge pumps. However bilge pumps are for pumping out water and not specially for propulsion, making them less efficient. Furthermore, the lack of propeller guards makes the bilge pumps a safety hazard to anyone handling the ROV. Lastly, bilge pumps are more energy intensive and would quickly use up the designated power quota. Thus, the safer and more efficient Seabotix thrusters were chosen for the ROV propulsion system.

Cameras

Design Description:

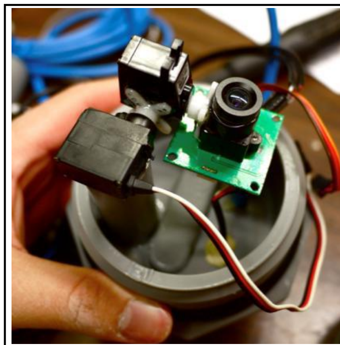


Camera design

There are three types of cameras on the ROV: regular (fixed), one-servo, and two-servo. Fixed cameras cannot pan in any direction, and the image can only move as the entire ROV moves. The one-servo cameras placed inside plastic cylinders can rotate along a single axis, providing a 180° field of vision. The two-servo cameras placed inside plastic domes can span an entire plane with two axes of rotation. For each of the plastic containers, a hole is drilled to allow wires to pass through, and then waterproofed with silicon. The area between the cap and the plastic container is also filled with silicon for protection and waterproofing. Finally, a flat Vex piece is connected to the cap so that the camera can be connected to the ROV frame.

Design Rationale:

The two servos camera includes two servos attached to each other at a 90 degree plane so that the camera can pan both left/right and up/down. A dome was used as the primary choice for enclosing this camera, as it could easily accommodate for the larger range of movement that the two servos would provide. Using a dome also reduces any uneven distortions for the camera and helps to create a fish eye effect for the camera image. Because the cameras from last year were still intact and fully functional, they were reused this year to minimize costs. However, because there was a change in the control system, the cameras had to be rewired and re-waterproofed. Instead of having the power, ground, and servo wires separated from the signal wire, this year all of the wires were merged into the Seacon in one single batch. Power goes to terminal 1 on the Seacon, Ground goes to 2, Signal goes to 3, and servos are connected to the remaining two connections. Those changes were all made in a single effort so that all cameras have the same input, which simplifies the programming process. Instead of using separate power lines for 12V and 5V power, a single 12V line was used to power the camera, and then stepped down to 5V with a 5V regulator in order to power the servos. By doing this, the number of lines coming out of the camera was reduced. After the connections were soldered into place, the team waterproofed the connections using heat shrinks and silicon. Heat shrinks were placed over the soldered sections of the wire, and silicon pumped into the heat shrinks for waterproofing.

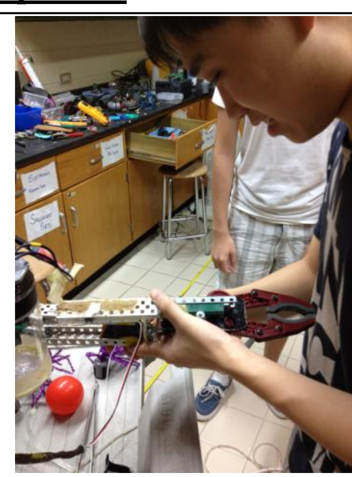

Camera with two servos

Design Rationale: Mission Tasks

Manipulator

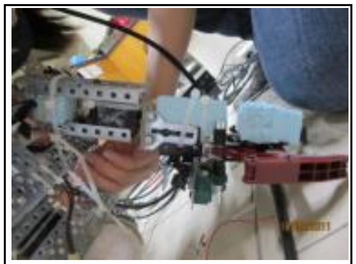
Mission Task:

To maintain a firm hold on and to manipulate cylindrical objects of varying diameter (from a minimum of 1.5 inches to a


CEO Kevin Ku handling the manipulator

maximum of 3 inches) as the ROV moves or accomplishes other missions.

Design Description:


The manipulator

The new arm is an improved version of the mechanical arm used last year. The electrical system was improved to prevent the mechanical arm from twitching due to the lack of calibration between the electrical system and the servo. Furthermore, to combat the difficulty in opening the claw after grabbing an object, a spring has been installed to introduce an additional force pushing the sides of the claw apart, facilitating this aspect of the claw's operation. Unfortunately, this also reduces the force on the item being gripped, and thus to bolster the strength of a closing the claw and securely holding the object in question, the clamp has been remade as well. It consists of two halves of a 3-inch PVC pipe cut in such a way as to allow for overlap, not only serving a spectrum of diameters, but also, with its silicon coating, improving the grip on the object.

Design Rationale:

The arm underwent several revisions from beginning to end. The original design involved a series of gears converting the linear actuation to the rotation of the two sides of a claw. The source of the actuating force is the transfer of pressure through tubing connecting a syringe on the shore and a syringe attached to the body of the ROV frame in such a manner that the extension of the syringe plunger rotates each side of the claw to close and the contraction of the syringe plunger opens the claw. However, there were several stumbling blocks that stood in the way of stable and efficient operation. While water is non-compressible, even small amounts of air greatly reduces the ability of the fluid within the tubing to transfer the actuation from onshore to underwater, at times rendering the manipulation of the arm near impossible. Opening the arm was found to be particularly challenging, a phenomena most likely due to the aforementioned problem and a tendency for the gear to shift instead of turning due to the torque applied by the plunger's actuation in converting the linear motion into rotational.

To address this issue, the spring was strategically placed to have the greatest impact, pulling the claw open more readily. However, to compensate for the detrimental effect this solution had on securely holding the objects, the claw shape was improved to fit together and overlap as it fits for multiple radii. To increase the underwater friction, a layer of silicon was also added to the gripping surface of the claw.

Suction Device

Mission Task:

To remove a sample of fuel oil from inside the tank by drilling through the hull, simulated by first poking through a layer of petroleum jelly (Vaseline) covering the opening of a platypus water bottle and then extracting a sample of the liquid from within.

Design Description:

The suction device consists of three 60 mL syringes whose plungers are glued together. The outer two syringes have connected tubes at the end which merge onto a metal piece for support and stability, in order to extract water samples. A cone tip on the end of the two connected tubes helps penetrate the jelly while


Suction device

preventing it from contaminating the water sample. The water sample enters the tube from the open base of the cone. The tube on the middle syringe connects to a fourth syringe onshore with which a team member can pump water into the middle syringe, thus causing simultaneous movement of all three connected syringes.

Design Rationale:

The design of the suction device was based off of the one from last year, which was simple, yet effective. Since pushing through the jelly only requires motion in one direction, which is easily achieved through movement of the ROV, on-board power was not required. This reduces the chances of electrical failure and prevents the control box complications. Connecting the suction device to the onshore tether made it easier to control.

A couple of improvements have been made to last year's design. Since the sample bucket for this year is horizontally placed, the old L-shaped metal piece on the suction device has been replaced with a straight, less malleable metal rod taken from a clothes hanger. Due to the extra layer of petroleum jelly, there was the challenge of pushing through the jelly without getting any inside the tube. The tube opening has to remain clear in order to extract the water sample; however, the suction may potentially suck in petroleum jelly and clog the tubes. This problem was solved by attaching a cone tip, taken from a glue bottle, to the front of the tubes. The water can still go in from the open base of the cone with the suction of the syringes, while the jelly simply slides past the cone. The cone also helps with aiming the entire suction structure through the PVC pipe. Furthermore, the cone covers the sharp tips of the metal rod for added safety.

Patch Dispenser

Patch dispenser

Mission Task:

To seal the hole in the oil tank, simulated by attaching a Velcro patch over the water bottle opening.

Design Description:

The patch dispenser is made from a 1½ inch PVC pipe with 4 rubber bands forming a # shape. The design utilizes tension to hold the handle of the patch in a horizontal position. During the mission, the propulsion motors drive the entire ROV towards the bucket, and, with help from a fixed camera, aim the patch toward the opening.

Design rationale:

In order to reduce control box duty and avoid excessive issues with the electrical system, the patch was mechanically operated. The rubber bands were chosen to make the tension easily adjustable. There needs to be enough tension to hold the handle of the patch in place, without having excessive grip, which prevents the patch from being attached onto the bucket opening through Velcro cohesion.

Measuring Device

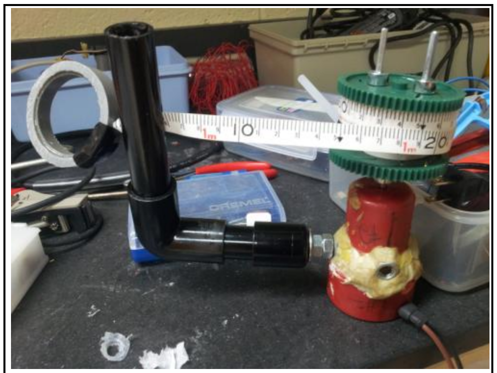
Mission Task:

To determine the length of the shipwreck by measuring the distance between two PVC pipe markers on the ship.

Design Description:

The measuring device is made from a bilge pump with tape measure coiled around the coiler. The tape measure is connected to a PVC ring that goes on top of the ½-inch marker. The ring loops around the marker and the ROV moves to the second marker to determine the distance between the two points, using a camera to read off the tape measure. Afterwards, the ROV rises to pull the ring off the marker and the bilge pump turns on to retract the extended tape.

Design Rationale:



Measuring Device

The first design involved using a screenshot from the camera and software to determine the distance between the two designated points. A ruler is attached so that it would be in the camera screenshot. Then using ratios, the distance between the two designated points can be determined by using the ruler in the screenshot as a scale. The design was replaced due to several reasons. First, it required the ROV to take the screenshot at the center of the two points, which was difficult to achieve. Furthermore, the protective dome shell for the camera would distort the ratio and make the calculated distance less precise. The rough camera resolution also adds to the error.

The second design involves a measuring device with two couplings that would fit over the ½-inch PVC markers with a string used to indicate the distance between the designated points. One of the couplings is fixed on the ROV with the string free to move through, while the other coupling is to be placed on the ½-inch PVC marker that will be removed once the measurement is observed using a camera placed on the ROV. The first coupling would be placed on the ½-inch PVC marker by using rubber bands that suspend the coupling, similar to the design of the patch dispenser. Eventually, this design was replaced because it was too difficult to place the first coupling on the PVC marking and remove it. Also, once the measuring device was removed from the shipwreck, there would be a long piece of string two to three meters long dangling from the ROV that could potentially hinder future missions.

The third and current design is a revision of the second design. Rather than having two couplings, the coupling attached to the ROV is replaced with the bilge pump that has the function to coil the measuring tape. In addition, the other coupling is replaced with a thin PVC ring that simply goes over the ½-inch PVC marker. Since the tape is initially coiled, the ring will naturally be held in place and there will be no problem with the ring floating around. The bilge pump also allows for a stable and consistent functioning system that can operate underwater without any risk of damage from water. A PVC device is also attached to the bilge pump in order to guide the tape measure so that it will recoil smoothly and be easy to read from the camera.

Challenges and Solutions

The measuring device presents many challenges. The first is: the mission is conducted underwater, making any image or ratio calculating methods inaccurate and difficult to conduct. Also, the two markers are short ½-inch PVC pipes that do not have big footprints, thus making sound wave or laser related measuring devices more difficult to use. The best solution devised was to take a rather simplistic and low-risk approach, and use a physical tape measure to measure the distance between the two markers. Minimal electrical components are required and the bilge pump is fairly low-risk when functioning underwater.

Once the first step was established, the second challenge was being able to cover a range of distances. Ranging from 2.5 to 3.75 meters, the distance of the shipwreck exceeds the ROV body frame length; thus, the ROV has to move from one marker to another to measure the distance. This presented yet another challenge: securing one end of the tape measure to the marker. Numerous methods were tested, and the final solution was simply using a ring that would loop over the marker while the ROV pulled away slowly towards the second marker.

Lessons Learned

Thanks to our dedicated members, many of our new, less experienced team members were able to learn a variety of technical skills this year. For instance, we learned how to carefully place electronics in the waterproof box without damaging anything, and we gained adept skills in using the soldering iron with a hot flux and desoldering wick since we did not have access to a hot air rework station. Additionally, many of us also learned how to waterproof cameras and wires, using electrical tape, silicone glue, or heat shrinks, and also that the heat shrink had to be placed before soldering two wires together.

Another important lesson we learned this year was the importance of communication and efficient teamwork. Most of our team members were second year participants, and some were first year participants; thus, for the first couple of months we did not know each other and were hesitant to ask each other for help and advice. However, as the team got to bond and know each other better, we became better at communicating and collaborating with one another. Through our teamwork, we have learned to appreciate all our different personalities and become great friends.

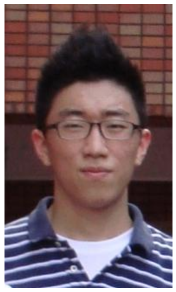
Future Improvements

- Have a set weekly meeting where members can discuss and develop new ideas.
- Instead of using PVC pipes, we could assimilate an adjustable buoyancy system.
- Use software to prevent overextension of servo in order to prevent servo gears from breaking.
- Better bundling of the wires, camera, servos, and regulator inside the camera to prevent them from hindering the movement of servos.
- Implement an emergency switch to surface the ROV in case of power or signal interruption.

Personal Reflections

Loren, Second Year Tigersharks Member, Pilot of the TS-03:

This being my second year working on the ROV, I've enjoyed the privilege of seeing the year to year improvements on both the design and the teamwork front. Using the same basic designs as last year, we've modified our tools to work in terms of this year's task. I've come to appreciate the modular design we implemented as part of our ROV last year, as the components we used last year are either still relevant or easily removed. In keeping true to the one-size-fits-all theme of our ROV, I feel like our solutions are getting more and more elegant as we refine them.

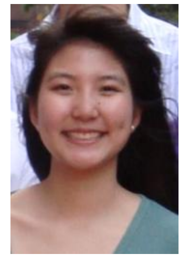


Alvin, First Year Tigersharks Member, System Engineer for the TS-03:

Since this was my first year, it was mostly a learning process for me. I've come to understand the buoyancy and drive theories that are relevant to the ROV. Teamwork is integral; it is what brings everything together amidst everyone's different schedules. I hope to contribute more next year!

Gregory, First Year Tigersharks Member, Camera Engineer for the TS-03:

As a new member, waterproofing and wiring were new to me in ROV this year. Initially, I was very tentative about the delicate electrical equipment. Eventually I managed to pick up the skills. Learning-on-the-job proved to serve me well and I learned to be more patient and cautious on waterproofing. I am glad that I have gained experience in waterproofing and a deeper understanding of problem solving in engineering.



Sarah, Second Year Tigersharks Member, Integration Officer of the TS-03:

We should start earlier so that there is more time for troubleshooting and refining our designs. The brainstorming process was very useful, and everyone's ideas were well considered during our meetings. The good thing is that our different team specialists met together to discuss various different angles of the same design, analyzing the waterproofing, the electronic capability, and the mechanical structure of the design at the same time, therefore increasing the efficiency of the brainstorming and design process. The waterproofing process was already quite refined from previous years of experience, which cut down on trial and error time a lot.

Acknowledgements

We would like to thank:

- Dr. Hartzell, our principal, and Dr. Hennessey, our superintendent, for their financial funding and confidence in us. Without their support, *Tigersharks* would not be able to respond quickly to clients' needs.
- Dr. Garcia for his unwavering support
- Mr. Simonton for giving up his valuable weekend time for our water tests. We would also like to thank him for his patience and guidance, and for lending his classroom for us to use as work space.
- Mr. Tsao for his connections to Taiwanese manufacturers and hardware stores.
- The Taipei American School for allowing us to explore our passions and for letting us use its facilities
- Marine Advanced Technology Education Center!

Financial Report

Income

Donations to TAS Robotics Programs	175000NT

Expenditure

Category	Description	Price (NT*)	Shipping cost	Total Cost (NT*)
Mission Props	PVC parts	2835	0	2835
	Reducer bushing	74	0	74
	PVC glue	189	0	189
	PVC cutter	799	0	799
				3897
Electronic	PS2 controller and peripherals	1950	393	2343
	Seacon connectors**	64008	10669	74677
	Integrated circuit microcontroller	5560	2376	7936
	USB programming interface and motor drivers	13018	1005	14023
	ROV mainboard	3324	2653	5977
	USB gaming capture	990	0	990
	Tether	2200	0	2200
	Misc electronics	758	0	758
				108904
Sensors	Compass and gyro sensors	11744	533	12277
	Temperature and humidity sensor	882	818	1700
				13977
Servos	Camera servos	2742	0	2742
	Arm servos	1809	0	1809
				4551
Camera	Lock and Lock box	457	0	457
	Camera	3900	0	3900
	Kodak underwater camera	2990	0	2990
				7347
Other supplies	Soldering stations	2608	695	3303
	Dremel	3520	0	3520
	Vaseline	163	0	163
	Misc hardware (zipties, lighter..etc)	1732	0	1732
				8718

* New Taiwan Dollar
** Seacon intended for long term use

Total cost: 147394 NT
4994.99 USD

Account balance: 27606NT
935.53USD

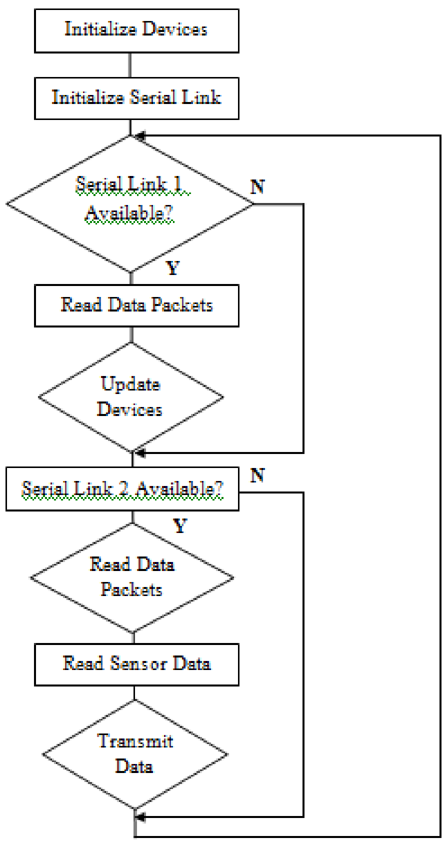
Development Schedule

TS-03 Development Schedule

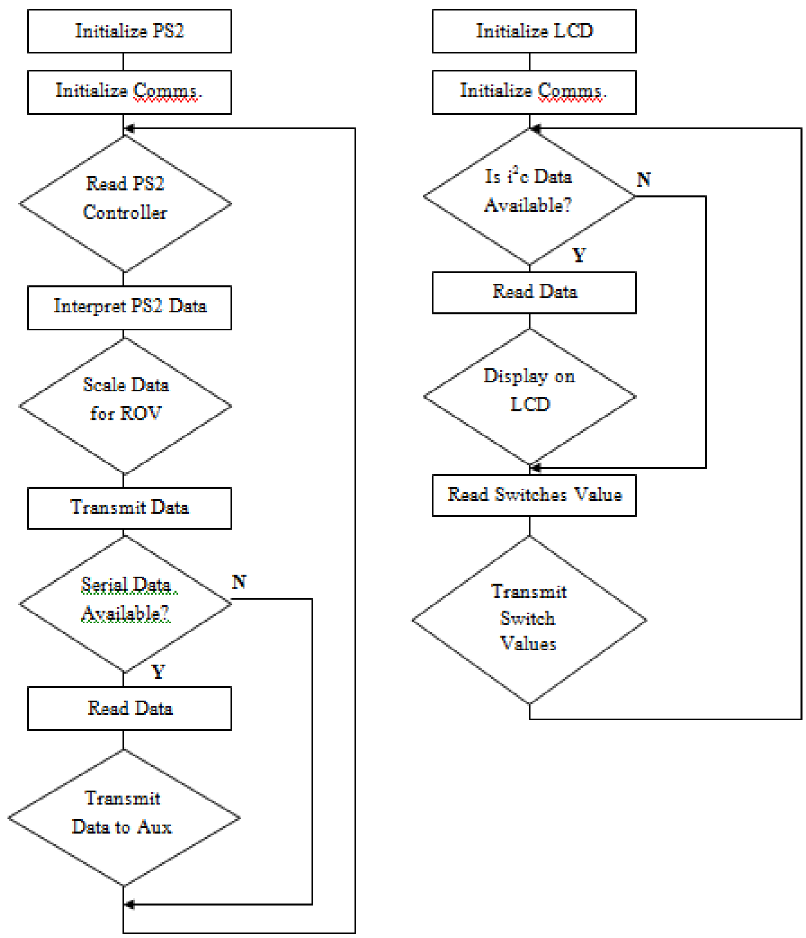
	Project ID	Project Manager	Description	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Phase 1	1	Kevin	Initial Deisgn + Feasibility																								
	2	Kateline	Reusability Evaluation																								
	3	Mandy	Procure Parts																								
	4	Gregory	Waterproof Box Design + Construction																								
	5	Jason	Manipulator Design + Construction																								
	6	Eric	Suction Device Design + Construction																								
	7	Anthony	Control System Design + Implementation																								
	8	Gregory	Camera Construction																								
	9	Sarah	System Integration																								
	10	Emily	Phase 1 Testing																								
	11	Kevin	Reevaluation																								
Phase 2	12	Jason	Manipulator Reconstruction																								
	13	Eric	Patch Design + Construction																								
	14	Anthony	Implementing humidity sensor, compass, LCD																								
	15	Loren	Distance Measuring Tool Design + Construction																								
	16	Gregory	Backup Camera Construction																								
	17	Alvin	Metal Detector																								
	18	Arthur, Annette	Ensure Safety Guidlines Are Met																								
	19	Mandy, Kateline	Tech Report																								
	20	Sarah	System Integration																								
	21	Emily	Phase 2 Testing																								
Phase 3	22	Kevin	Finalize Design																								
	23	Loren, Emily	Mission Training																								
	24	Jason	R&D New Arm																								
	25	Gregory	R&D New Waterproof Box																								
	26	Anthony	R&D USB-Control System Interface																								
	27	Sarah, Kateline	Manfacture Backup Parts																								
	28	Arthur	Packup for Orlando																								

tigersharks REMOTELY OPERATED VEHICLE

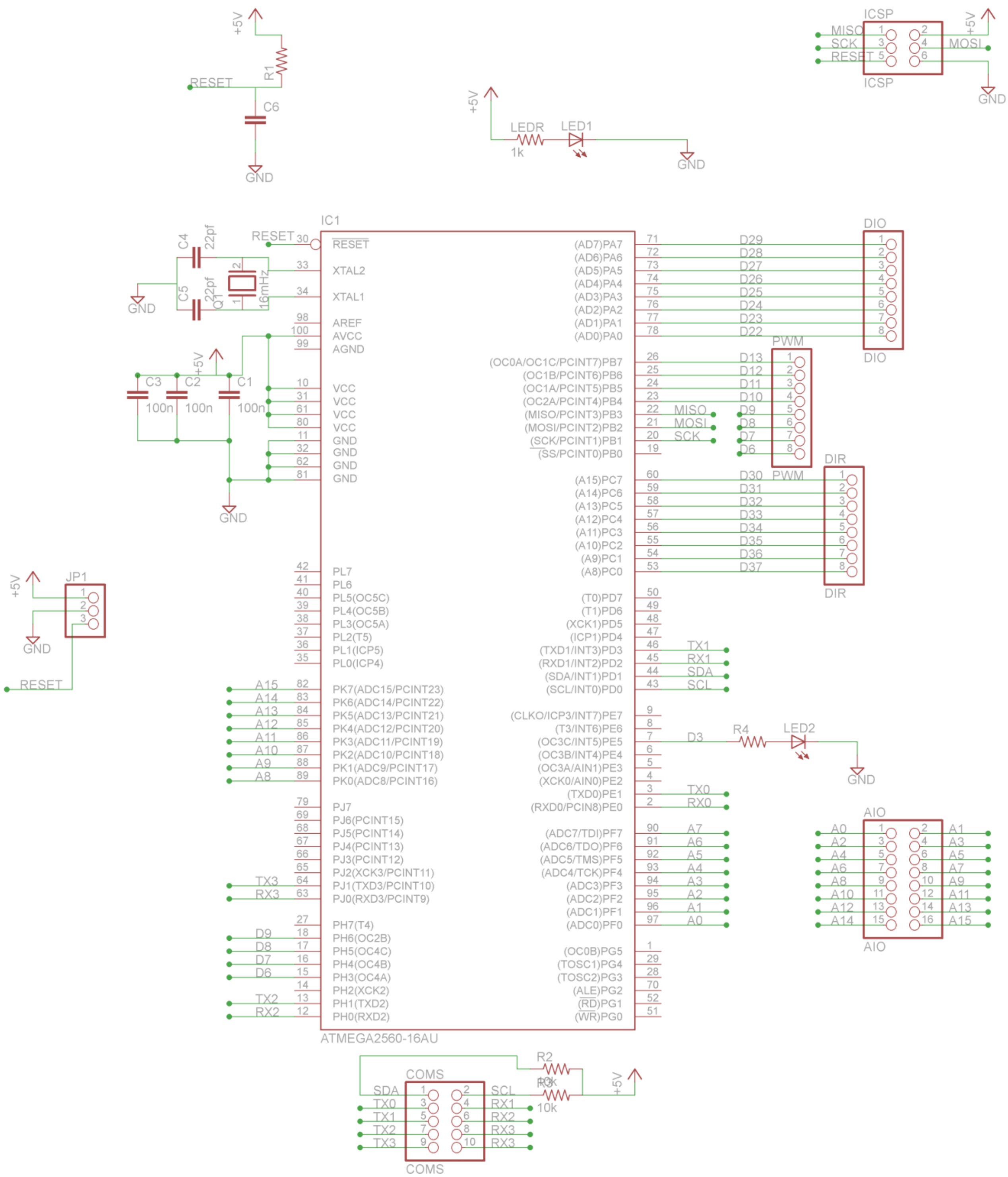
Software Flow Chart: Underwater



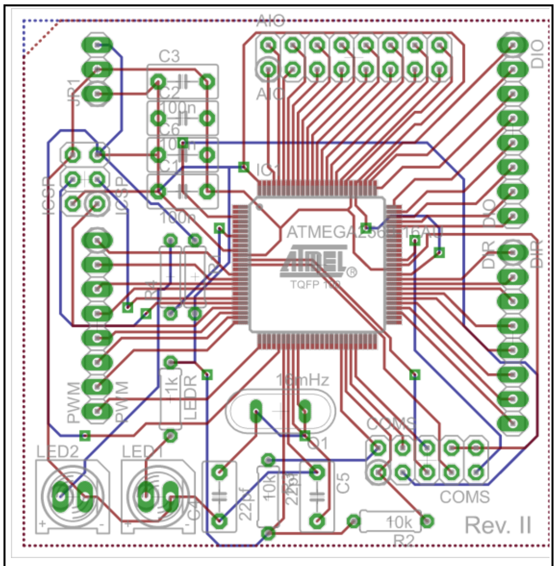
Software Flow Chart: Above Water



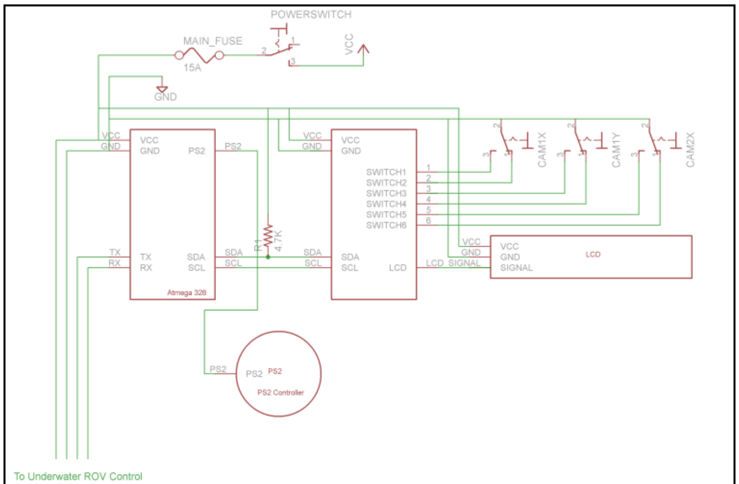
Electrical Schematics



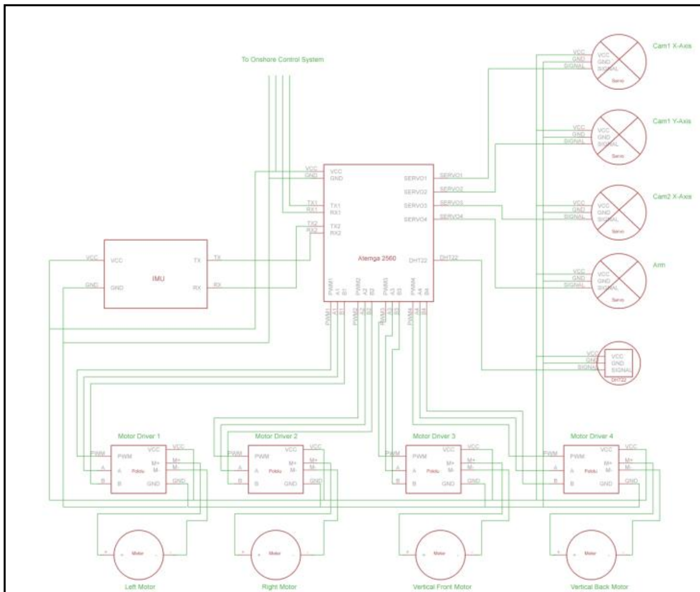
Electrical Drawings



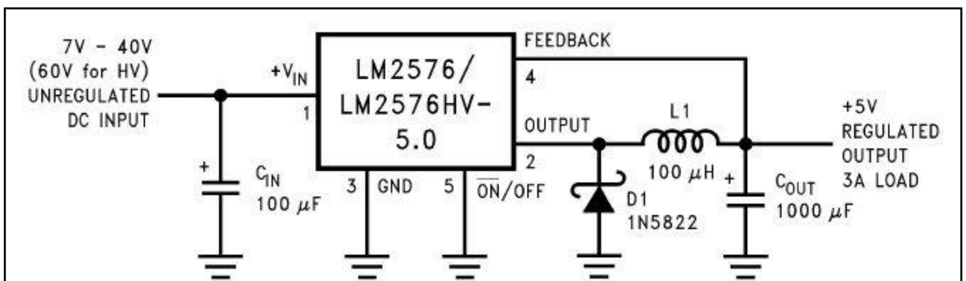
Board



Onshore Electrical System



Underwater Electrical System



Power Supply