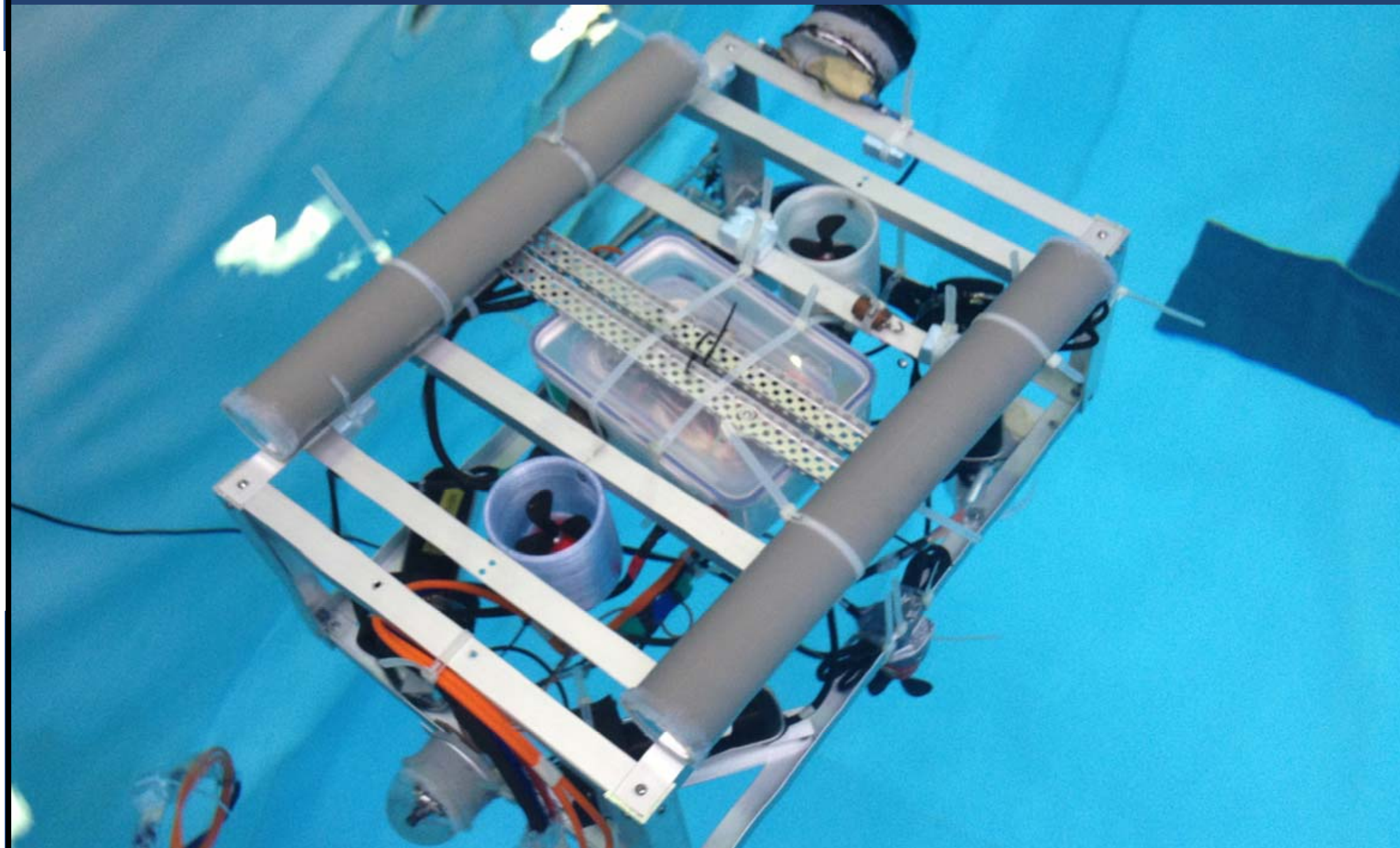

tigersharks co.

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

Team Members

Anthony Lin: Chief Executive Officer

Gregory Huang: Chief Executive Officer

Annette Wang: Chief Financial Officer

Alvin Choi: Chief Operations Officer

XiaoYang Kao: Chief Technology Officer

Joey Brebeck: Pilot

Young Chen: Design Engineer

Mark Chua: Regulatory Officer

Emily Huang: Public Relations Officer

Kevin Lin: Camera Engineer

Jin Suh Park: Mechanical Engineer

Emily Sun: Integration Officer

Edmund Tong (not travelling)

Mentor

John Simonton

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Abstract

From last year's 15th place finish at the 2012 ROV MATE Competition, Tigersharks is prepared and confident to build upon the challenges and dissonances gleaned from previous years to transform hardship into success. Tigersharks has constructed a remotely-operated vehicle designed to complete maintenance work on the seafloor. With help from our pilot, the TS-04 is able to complete a primary node, install a scientific instrument on the seafloor, and construct and install a temperature sensor over a hydrothermal vent to measure the temperatures at specific times. After removing and replacing an Acoustic Doppler Current Profiler, the vehicle can finally remove biofouling organisms from structures within the observatory. In order to accomplish these tasks, the vehicle is equipped with two omni-purpose pneumatic claws and is powered by 4 Seabotix thrusters and 4 bilge pumps. Additionally, a water cooled control system is integrated into the ROV to reduce heat generated by motor controllers and a custom 3D printed control box with custom PCBs is also included in the ROV.

The following technical report describes the functions and features of the vehicle and presents in detail the design rationales and making processes of each component. This report also elaborates on troubleshooting techniques, challenges faced, improvements and modifications, and includes a financial report covering the price and quantity of components used for the vehicle, reflections of what each member has taken away from this experience, and acknowledgements to individuals and organizations who have generously 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 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

I was first introduced to ROV back in 2010, at the time I had just started VEX and had no idea that ROV had ever existed. Which is why I consider myself extremely lucky to have been invited by the Vice President at that time to join Tigersharks. For three years, I have seen the company grow and blossom in terms of technical skills, design innovations, as well as team spirits. It has been a delight to have watched our fledgling recruits from the beginning of the year grows up into mature, strong-willed leaders who will surely have many opportunities to demonstrate their new found skills.

As this company further develops along the years, I am certain that we will prosper for the years to come as we recruit many more talented individuals who need a place to shine.

Anthony Lin

The 2012-2013 season for the TAS ROV Team is a year filled with intensive experimenting and learning. With more than half of the team from the 2011-2012 season gone as they move onto college, the team recruited 7 new members in the beginning of the year. The team also included new R&D sessions and brainstormed ourselves to our limits. With all these new components added to the team, I was expecting a lot of chaos in the beginning of the year. However, each and every single one of the members came into work sessions with a dedicated and passionate attitude, accompanied by ingenious ideas and skills. The team clicked together nicely and the year went by smoothly. It has been a real pleasure for me to be part of this talented group that is fully devoted into the goal of the company: To build a highly maneuverable, reliable, and cost-efficient ROV.

With the team ever more experienced, I am confident that the team will continue to do an absolutely brilliant job on making the best TAS ROV yet.

Gregory Huang

CEO Anthony working with Kevin and Joey

Theme and Mission Overview

The ocean, a source of food and minerals, is one of our planet's most valuable resources. It plays a crucial role as a climate buffer, removes carbon from the atmosphere while supplying oxygen, and provides ways for transportation. The planet's largest ecosystem affects everyone and the need to better understand this resource is apparent. Unwise practices the human race has adopted have created a litany of problems in the ocean ranging from diminution in biodiversity to over harvesting of resources.

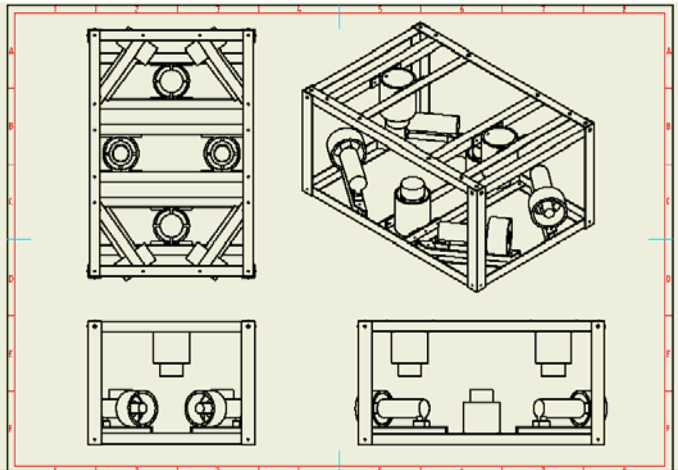
Essentially, the amalgamation of instruments and sensors about the floor of the ocean and from miles above the earth will provide us with a more comprehensive perspective of the ocean which will in turn allow us to make better decisions involving coastal and ocean decisions. Utilizing data from a global system of ocean observatories, scientists will be able to predict and monitor the impact of physical, chemical and biological factors under water. Such predictions are vital to our understanding of the ocean. The construction of the Ocean Observatories Initiative, an initiative to observe such factors, is led by researchers and scientists from the University of Washington have recently released a request for proposals for ROV service which the Tigersharks co. has promptly responded to. The proposal requests for the extension of the nodes and instruments on the Axial Seamount.

A hydrothermal vent field is located north of the Axial Seamount and University of Washington's Axial Seamount Hydrothermal Emission study aims to better understand the area. The goal of the Tigersharks is to help expand the ASHES study, focusing on the Axial Seamount site of the Regional Scale Nodes that when complete, will be the largest cabled observing system in the US. The RSN cabled observatory is a system of scientific underwater terminals on the Juan de Fuca plate composed of seven primary nodes. Each node consists of the Backbone Interface Assembly and the Science Interface Assembly.

In the 2013 MATE ROV Underwater Robotics Competition, Tigersharks will employ a custom-made ROV, the TS-04, to complete routine maintenance work, install nodes and deploy instruments. The TS-04 features many features of the TS-03 but is vastly improved and tailored for the specific services for the ASHES study. TS-04 will begin the mission by installing the SIA so that it rests in the BIA of a primary node previously deployed at the ASHES site completely and then connecting the BIA to the backbone cable via the Cable Termination Assembly (CTA). For power and communication, the ROV will then connect an ocean bottom seismometer (OBS) to the SIA by first removing the OBS from the elevator and depositing it in a designated location. The TS-04 will then proceed to open the BIA door and connecting the OBS cable to the BIA. Next, the TS-04 is will use a temperature sensor to take the temperature of a vent field over a period of six minutes and create a graph. The TS-04 will then replace the Acoustic Doppler Current Profiler (ADCP) from mooring platform by safely powering off the platform, opening the hatch, replacing the existing ADCP, locking the hatch and reconnecting power. Finally, the TS-04 will locate and remove any biofouling organisms from the site.

Design Rationale: ROV Components

Structure: Frame, Buoyancy, and Thruster



Technical Diagram of the ROV structure

Design description:

This year, we replaced VEX aluminum channels with solid aluminum L channels for the ROV frame. The entire frame was designed in a rectangular shape with multiple horizontal L channels and four C channels supporting the Seabotix thrusters and bilge pumps. Four Seabotix thrusters were positioned in separate angles while the four bilge pumps with propellers were mounted vertically in a cross shape on to the frame. Two cylindrical buoyancy tanks and a measured system of masses and floatation foams were used to achieve near-neutral buoyancy for the ROV

Design rationale:

We chose solid aluminum L channels instead of VEX aluminum channels used in the previous years because solid aluminum L channels are more cost efficient compared to VEX channels due to its availability in Taiwan. Additionally, aluminum L channels possess less risk of rusting or leakage and are therefore ideal for maintenance and fast preparation before the missions. The ROV frame was designed in a rectangular shape due to the simplicity of manufacturing and the structure stability that this design provides. The multiple horizontal L channels and the four C channels not only provide a mounting frame for the thrusters but also extra structure stability.

Due to the complexity of the mission proposed this year, more accurate maneuverability was required from the ROV. Instead of having a traditional drive where thrusters are parallel to the ROV frame, the placement of thrusters was positioned at 50 degrees to the corner of the ROV frame. As a result, the omnidirectional drive allows the ROV to move in any direction, independent of rotation. An omnidirectional drive is useful in situations that require higher mobility and less traction than a standard drive system. This design is able to cater to the pilot's preferences, requiring less thought to adjust to the various conditions during a mission.

Motors

Seabotix Thrusters

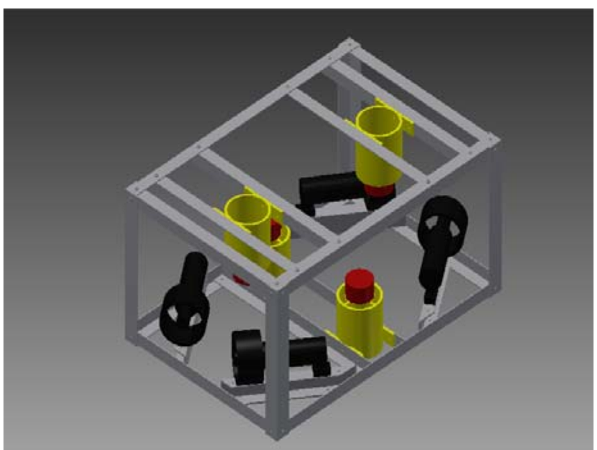
Design Description:

The motor controllers are individual circuits separate from the superchip underwater. Each motor utilizes 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 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.

Design Rationale:

The design rationale of the motors and their orientation is discussed in the propulsion system section.

Propulsion System

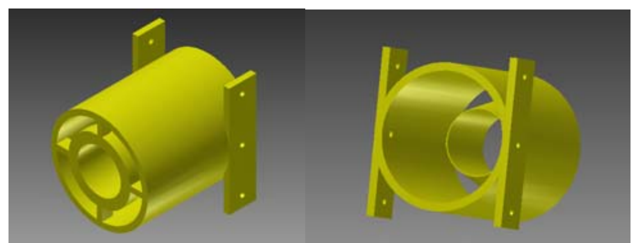


CAD model of the ROV structure and propulsion system

Design description:

The propulsion system consists of both Seabotix thrusters and bilge pumps. Seabotix thrusters maneuver the ROV in the x and y-axis whereas the bilge pumps maneuver the ROV in the y-axis. Four Seabotix thrusters and four bilge pumps were chosen for balance between power and maneuverability. The Seabotix thrusters are located at each of the four corners of the ROV frame, with each thruster making a 50 degree angle with the front/back of the ROV so that it is capable of omni-directional drive. The bilge pumps are placed towards the center in a cross pattern. Two bilge pumps (the center front and back ones) face up and the other two (the center left and right one) face down to ensure that the ROV moves with equal (or near equal) speeds going up and down.

Since the bilge pumps did not come with factory made casings to protect the propellers, custom 3-D models using Autodesk Inventor were created. The 3-D models were printed out using a 3-D printer (the material used was ABS plastic).

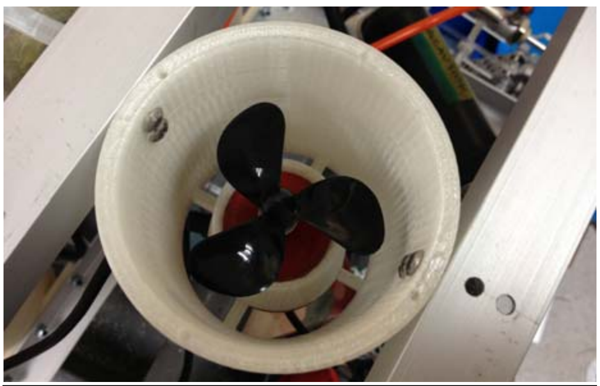


CAD model of the bilge pump casing

Design rationale:

The Seabotix thrusters were used for the ROV as they proved to be reliable and efficient the previous year. The thrusters were angled at 50 degrees to provide sufficient thrust moving forwards and backwards while allowing a steady strafing motion. Additionally, due to a lack of accessibility of Seabotix thrusters, we used bilge pumps and propellers for vertical propulsion. Since bilge pumps work much more effectively in one direction, the bilge pumps are used only for surfacing and descending, as well as minor adjustments to the ROV depth, Thus, we attached two bilge pumps facing up and two facing down. This way, the depth at which the ROV travels can be controlled evenly, with the two top facing motors performing most of the work on the way down, and the two bottom facing motors performing most of the work on the way up.

The bilge pump casings were designed to protect the rotating propellers as well as to provide mounting points on the ROV frame. The tube shaped casing surrounds the entire bilge pump and propeller in order to protect from any debris or obstruction. A cone structure surrounds the upper portion of the bilge pump to create smooth water flow, thus allowing for better thrust efficiency. Mounting bars with bolt holes were added to the side of the casings to provide stable mounting points on the ROV frame.



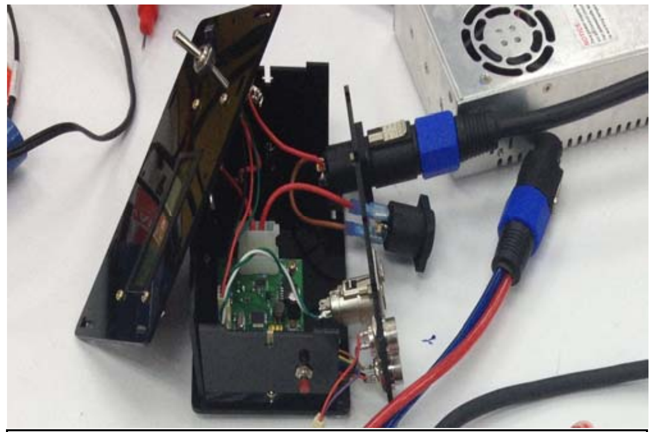
Propulsion System: Bilge Pumps

Control System

On shore/Surface Control Box

Design Description:

The on-shore control box is responsible for interpreting joystick movement from the controller and monitoring the ROV. The control system has to handle three different bi-directional serial ports (primary ROV, heads-up display, and a serial LCD), but since the atmega328 only has a single hardware UART, software serial had to be used. The display is used to display error codes from the ROV to simplify the debugging process. The box also has an ACS712 30-amp current sensor for current monitoring. On the back side, there are two Seacon connectors for power input and output, and a five pin XLR for camera signals and serial communication. Two other jacks are for the temperature probe and the PS2 joystick.



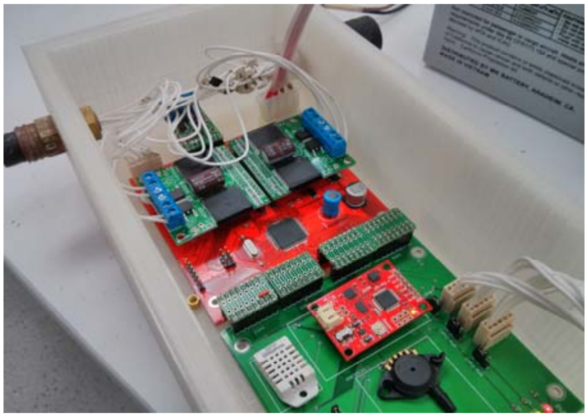
Inside of the on-shore/surface control box

Design Rationale:

We chose the current sensor to be placed in the on-shore system rather than on the ROV to accommodate for voltage drops along the tether. This means that the value returned will be as accurate as possible. The ACS712 is a surface-mount device, and since the maximum current is 20A, the PCB traces had to be very large.

The back connectors for the various IO signals were carefully chosen. The 12V input from the power supply and output to the ROV both had to handle 20A of current, which meant that connector choice was very important. Seacon connectors are rated for 20A each, so two of those were used.

Below shore/Underwater Control Box):



The 3-D printed below shore control box

Design Description:

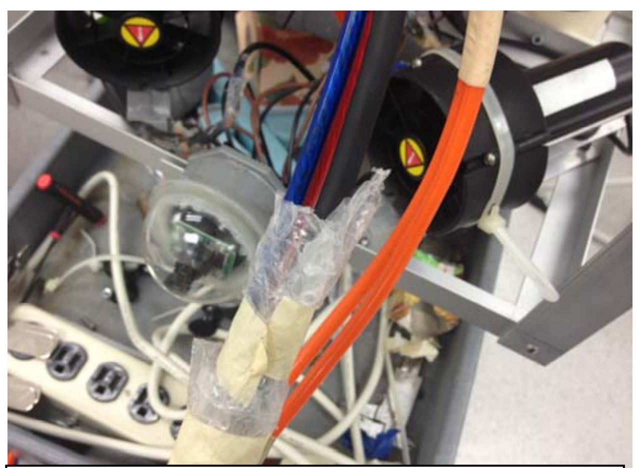
The underwater control box is used to interpret the signals sent from the on-shore control box and to translate into motor values, servo values, and under necessary locomotives on the ROV. An Atmega2560 is used to power the underwater control system due to the abundance of digital inputs and outputs. The box itself was 3D printed in PLA plastic from a MakerBot Replicator 2 and contains 4 Seacon ports for the control system's connectivity options. Unlike its predecessor, custom PCB's were manufactured to create a modular and compact system that is easily field replaceable by anyone on our team. The control system also marks our company's transition from DIP styled components to SMT styled components due to the smaller footprint of surface mount devices. There is also a peltier cooler located within the control box that is responsible for cooling the air in the control box to neutralize the heat mainly by the voltage regulator and motor controllers. There is also an IMU for providing information about orientation for the ROV.

Design Rationale:

The control box was 3D printed for a more compact and customized option versus the Lock and Lock boxes used last year. The 3D printed box is not only waterproof but the lattice fill from 3D printer also creates a very rigid structure. Custom pcbs were used because a lot of time was wasted last year trying to replace and find problems in the control box. With custom pcbs, all the components such as motors, sensors, and connectors, are all field replaceable saving a lot of time. Our shift to surface mount technology is due to the significantly smaller footprint a surface mount device has over a thru-hole device. This allows our control system to be further compacted to save space. A peltier cooler is also added to take advantage of the water surrounding the ROV. Using a peltier cooler, heat generated from the control system can be dissipated into the surrounding water.

System Block Diagram: See Appendix D

Tether



The three tethers with different colors

Design Description:

Two tethers connect the ROV to the onshore control system. One carries signals from the underwater control system to the onshore control system and consists of pneumatic tubing, a six-core Seacon cable, and two wires responsible for power. The Seacon contains six wires: a transmits signal from the main onshore control box to the ROV control box, a receive signal the other way, camera signal 1, camera signal 2, camera signal 3, and one wire that carries the camera ground. The speaker wires are single lines responsible for supplying power. One supplies 12V while the other is ground. The pneumatic tubing for the claw is also attached to this tether for organizational purposes. The other tether receives readings from the temperature probe and consists of three wires: one for power, one for ground, and one that transmits the signal. The temperature sensor's separate tether minimizes interference with the central control system as it connects directly to the surface control system. For flotation purposes, bubble wrap and foam blocks are secured onto the tether to make it more neutrally buoyant, and prevents it from interfering with the movements of the ROV by dragging it downwards.

Design Rationale:

Since the tether worked well last year, we did not redesign this year's tether and only made slight modifications, which cut back on cost. We changed to thicker wires due to a higher demand for current and attached new bubble wrap and foam to maintain neutral buoyancy.

Cameras

Twin servo front camera

Design Description:

The cameras that the TS-04 used this year are basically the same as the cameras used last year. The cameras were mounted in a PVC case with a screw-in acrylic dome over it. The wires go out of the casing and connect with the seacon wires. There are three types of cameras: a twin-servo camera that allows 2-way motion, a single-servo camera that provides a 180 degree view, and a no-servo camera that provides

A single Servo Camera

stationary image. We used teflon tape to waterproof the modules. We applied roughly 4 layers of teflon tape around the threaded part of the PVC casing. This prevents potential leaks caused by the gaps between the acrylic dome and the PVC casing. There were also bubble wraps attached to the bottom of single-servo camera acrylic cylinders located at the bottom of the ROV.

Design Rationale:

We kept the design from last year because of the tremendous advantage servos gave us. We were able to look around without turning the ROV at all, which provided efficiency in the missions. Although the modules themselves did not change a lot, there were major improvements in waterproofing procedures and they drastically increased the reliability and the repairability of the cameras. We opted for teflon seal around the threads between the PVC casing and the acrylic dome, instead of acetoxy seal. Teflon tape could surround the threads in a manner of minutes, and they do not seal up the threads. This makes the camera a lot more repairable, because once there's a problem it could be unscrewed immediately, and once the repairs are done, a new teflon layer goes on and completes the repairs. This drastically reduced our response time to camera problems from a matter of days to a matter of minutes. This is one of the most prominent products of our R&D sessions. The cameras also had crash protection. For the single servo cameras located at the bottom of the ROV, it was inevitable for the cameras to face some occasional crashes onto the bottom of the pool. To tackle the problem, we applied bubble wraps at the bottom of the acrylic cylinder that covered the camera. The bubble wraps served as a buffer when the camera hits the bottom of the pool.

Teflon wrapped around camera to prevent water leakage

Design Rationale: Mission Tasks

Omni-purpose Pneumatic Claw

Claw 1 of the ROV

Mission Task:

Claw 1: Deals with the temperature sensor tasks, removes old ADCP, inserts new ADCP, locks hatch, and removes biofouling organisms.

Claw 2: Transfer and install the SIA into the BIA and remove, deploy, and insert the OBS cable connector into the bulkhead connector on the SIA.

Design Description:

The ROV is equipped with two claws, each of different design. The first claw is a traditional dual four-bar linkage that grips from two opposite directions. This claw is mounted facing the downward direction to better interact with objects to be picked up and moved around directly under the ROV. This claw interlocks when it closes over handles so it can withstand a great deal of turbulence without letting go of the object. The second claw is composed of similar four-bar linkage designs, but utilizes four grippers to actuate from four different directions. This claw is mounted in the forward direction to better reposition objects that must be manipulated horizontally while maintaining their orientation. Because pressure is applied from four different directions, the held object has no freedom of movement and is constrained to precisely the orientation in which it was picked up.

Design Rationale:

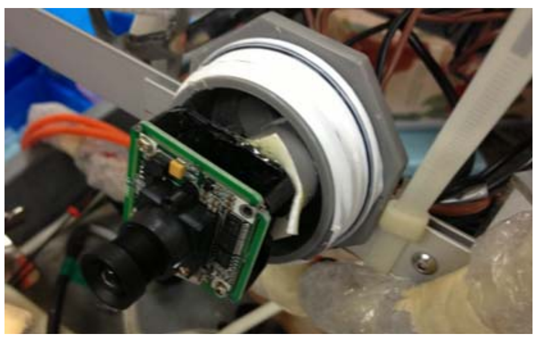
Both of these claws were built using the same design features. They actuate by using a double acting pneumatic cylinder. The cylinder provides a large force for both holding and releasing objects while maintaining mechanical simplicity, as they are comprised of one moving part and do not house any electrical components by themselves. This is superior to using a servo, as the range of motion needed for a claw is much smaller than what a servo provides, and waterproofing a pneumatic cylinder is much easier and more reliable. The claws are constructed with aluminum channels and acrylic pieces. This combination improves both durability and replaceability, as large components of custom designed acrylic can be laser cut out of sheets of acrylic with very high precision and low cost. Aluminum channels provide structural support for areas that experience the most stress. Thus, the robust design is both structurally sound and modular in nature, making it easy to maintain and reliable.

Challenges and Solutions

Waterproofing of Cameras:

A recurring challenge of the TS-03 was the waterproofing for the cameras. Because of the properties of acetoxy (which was the sealant we used last year), camera waterproofing was time-intensive due to the drying period needed. Because of the long waiting time, the lack of a completely dry acetoxy silicone layer mostly likely contributed to the condensation on the camera module after a water test. Another problem caused by the time needed to dry was that the limit hindered our repairing speed. If the TS-04 needs instant repair, we can't open up the acetoxy and reseal it immediately, as a new layer of acetoxy coating would take up too much time to dry up (usually a day or two). That's why the goal for the camera system on the TS-04 was "quick waterproofing", which aims to figure out a more efficient and repairable way to waterproof our cameras. We came up with waterproofing ideas such as teflon, wax, and hot glue in R&D sessions.

We experimented all these approaches with actual camera modules and examined which ones were both time efficient and reliable. First we tried dripping wax on the camera modules. Wax, although relatively faster to cover the camera module, demonstrated difficulty in accuracy as the liquefied wax had to be dripped onto the connections of the camera, and this causes the liquid wax to drip and flow all over the place and form gaps that are prone to leakage. Hot glue also experienced similar problems as the wax approach. In the end, teflon turned out to be the most effective method; it was fast to wrap around the threads on the PVC casing, easily removable, and completely waterproofed the camera module. Teflon was in fact so trustworthy we have only experienced a very minor leakage out of more than 10 water tests.



Teflon tape around camera modules

Anthony and Joey making filtering sand to make 45 degree joints

Building the props:

A non-technical challenge we faced this year was the unavailability of many prop materials. Due to our location in Taiwan, we were unable to find materials such as milk crates (milk crates are an uncommon packaging in Taiwan) and 45 degree joints. We were able to overcome this challenge by adapting our prop dimensions to fit the materials we could find in local hardware stores and making slight modifications to the manual instructions. To tackle the 45 degree joints, we had two approaches to the problem. First, we experimented with heat bending a 90 degree PVC joint, by adding sand into the joint and bending it while it was heated by a blow torch. The success rate were relatively low and it took up quite a lot of time. The other option was making two cuts to the 90 degree joints and using putty to stick the two parts together. That method worked and we ultimately managed to make our own 45 degree joints the cutting method instead of the heat bending method.

Communication:

This year, we often had problems with team communication. Because every team member had different schedules, it was often hard to have a set weekly meeting where members could discuss and develop new ideas. Thus, we were able to improve in this area by using google docs and google spreadsheets. Every member updated the documents and checklists, and we were able to track our progress and ideas.

Troubleshooting

In order to minimize the amount of time we spent on troubleshooting, our team always approaches problems with certain troubleshooting techniques. First, we always create drawings or markings that represent accurate measurements. This allowed us to anticipate and predict possible issues before they occurred and we were then able to discuss these issues as a team. We also tested the ROV in parts as much as possible so that we could change specific problems with parts of the ROV instead of redoing or redesigning the entire ROV. To ensure the efficiency of this technique, we made many components of the ROV removable, so that testing and modifying each part would be easier. For instance, the cameras were made separately and later attached with screws and the control box was initially attached to the main frame using zip ties and Velcro, allowing them to be easily removed from the frame.

In addition, we also noticed that using trial and error for some aspects of the ROV was more efficient than calculating the necessary measurements. For instance, we used the trial and error technique to maintain balance and the desired buoyancy for the ROV. In water tests, the ROV is tested in the water for buoyancy first. If the ROV is sloping or is too negatively or positively buoyant, it can be compensated by adding pieces of Styrofoam blocks or small weights.

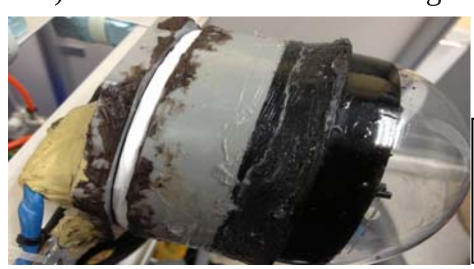
Lessons Learned

As with each year, Tigersharks has added a number of new members to the team to foster new ideas and innovation. Thanks to our dedicated veteran members, many of our new team members were able to learn a variety of skills this year. Fundamental skills such as soldering, waterproofing, testing, and safety procedures have been key to developing technical skills and many of us have also acquired the skills of waterproofing cameras and wires using electrical tape and silicone glue. Also, we have learned that heat shrinks have to be placed a certain distance away from the joint and also placed before soldering two wires together. Furthermore, Tigersharks has been fortunate to use new pieces of machinery this year, such as the 3-D printer, milling machine, and laser cutter. For example, we learned to use the laser cutter to cut pieces of acrylic disks instead of using PVC end caps for our buoyancy tanks to minimize unnecessary weight. Additionally, we replaced the Lock-and-Lock control boxes with a 3-D printed control box in order to alleviate weight and improve waterproofing on our ROV.

Most importantly, our team has learned the skills necessary to function and succeed as a team. Commitment, time management, and organization were key to successful teamwork, and we often ran into difficulty because everyone had different schedules. Thus, we improved in these areas by creating checklists. For instance, a "prop checklist" (see appendix B) was created, simplifying communication as each person could identify who had started which prop. This prevented multiple individuals from making the same props twice and allowed the team to check the progression of prop construction easily. 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 bonded, we were more open and willing to cooperate and collaborate with one another. Through our teamwork, we have learned to appreciate all our different personalities and become great friends.

Future Improvements

We will work toward improving how we mount the cameras onto the frame. This year, we used putty to secure the camera onto a sheet metal with 2-4 drilled holes and then secured the sheet metal onto the ROV frame. However, the metal was positioned to a specific spot and this became troublesome when we wanted to reposition the camera, as we would have to redo the entire mount. Because we now have easy access to a 3D printer, we can improve the camera mounting by designing a specific mount for the camera and 3D printing it. This ensures that if there is a problem in the positioning we can always make a slight change in the program and reprint the mount. Another improvement that we will make next year is to shift all serial communication to the RS-232 standard for lower data loss due to the higher potential (5v vs. 12v). Also we will be working towards data



Putty securing camera

packet recovery to minimize data loss through the tether.

Safety

At Tigersharks Co., safety is our number one priority in both the workplace and in the pool. First, to ensure safety during all tests, we always wait for an "okay" signal from the pool deck and check if swimmers are at least 5 meters away from the vehicle before the ROV is powered up. We have also incorporated a new Standard Operation Procedure (see appendix A) that will maximize safety and efficiency on deck prior to the missions. The list includes mostly electrical procedures (control box and camera set up) to prevent any type of harm that could be induced to the machine and/or personnel handling it.

Additionally, as basic precautions for ensuring that the ROV is safe for manual handling, cut edges of 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. Other wires connected to cameras are labeled with colored tape to ensure they are connected to the right ports. Additionally, all the motors are clearly labeled with caution signs and enclosed to prevent damage to nearby wires or personnel. To prevent danger caused by live wires, all the electrical components of the ROV are carefully waterproofed with heat shrinks on the wires that are filled with silicon and acetoxy.

Apart from safety precautions, we also have several safety features installed in our vehicle. Inside the control box, we have a humidity sensor, which allows us to check for leakage, and we also have a temperature sensor which allows us to check for overheating. Additionally, there is a fuse on the onshore control system that will blow if wiring becomes overheated due to excess current. This will cut off power to the TS-04 and prevent damage to the ROV, nearby equipment, or nearby personnel.

A pneumatic diagram is included in Appendix A after the safety checklist.

Reflections

Joey Brebeck, pilot for the TS-04: My first year in the ROV club has been a stupendous year. The unique experience of buying raw materials and fashioning an ROV from them has allowed me to learn several new skills, such as those required for operating the mill, laser cutter, and 3-D printer. Also, there is no problem that cannot be solved by the use of duct tape and zip ties. Our ROV club is split into three departments, Mechanical, Electrical, and Cameras; the three divisions work on their specific areas to boost efficiency and teamwork within each individual "department". Having worked in both the Mechanical and Camera department, I have aided my teammates in the measuring, drilling, and sawing necessary for constructing the frame, as well as the application of Teflon and silicone required for sealing the cameras. Working with my teammates has been a fun and enlightening experience. I look forward to attending the MATE ROV Competition.

Alvin Choi, Chief Operations Officer: This being the second year in Tigersharks Co., I've enjoyed the privilege of using the brand-new robotics lab and cutting-edge equipment such as milling machine, laser cutter, and 3D printer; utilization of such tools significantly improved the quality of our ROV in both efficiency and capability front. This year's creation of Tigersharks is a very unique and incredible piece of machinery that has put forward many challenges that we, as a team, have overcome efficiently. Tigersharks' ROV is capable of carrying out the mission tasks, put forward by its clients, with adequacy and thoroughness. Working with my colleagues has really improved both my skill sets and brought the team members of Tigersharks unified as one. In Tigersharks, I was able to learn a great deal out of mechanical engineering; however, robots are not just about gears and torques. Active communication fostered cooperation and teamwork, traits that contributed to our success in the construction of ROV. As I leave Tigersharks to pursue mechanical engineering in college, I am proud to possess the skill sets that I've gained from ROV experience.

Emily Sun, Regulatory Officer: As a first year member on the team, ROV has exposed me to a variety of learning opportunities. Whether it was learning to make adjustments on the camera mounts or assisting my team members with waterproofing, I was able to fully immerse myself in the problem solving of engineering. More importantly, I have also realized the key role of cooperation. The ideas of everyone on the team are essential to the construction of the ROV, regardless of department. Through our work days of brainstorming and trial and error, I have to say my experience on this team has been truly memorable. It's great to see how far our hard work has taken us and I look forward to the upcoming competition!

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.
- Mr. Simonton, 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, for providing this wonderful opportunity for us to compete with so many different teams across the world!
- The Taipei American School for allowing us to explore our passions and for letting us use its facilities!
- All the donors of the Robotics Lab for giving us such a wonderful workspace and giving us access to high-tech equipment.

tigersharks REMOTELY OPERATED VEHICLE

Financial Report for Tigersharks 2012-2013:

Income					
Donations to TAS Robotics Programs		150000 NT			
Expenditure					
Category	**Description**	**Price (NT)**	**Shipping (NT)**	**Total (NT)**	**Remarks**
Mission Props	PVC parts	3741.00	0	3741.00	
	PVC glue	350.00	0	350.00	
	PVC pipes	1660.00	0	1660.000	
	Corrugated plastic sheet	200.00	0	200.00	
	Plastic bucket	150.00	0	150.00	
	U-bolts	360.00	0	360.00	
Mechanical	Aluminum for frame	Market	Value	3000.00	Donation
	PVC (buoyancy tanks)	300.00	0	300.00	
Electronic	Wires	136.00	0	136.00	
	Integrated circuit microcontroller	3518.00	298.15	3816.15	
	ROV mainboard	2174.68	596.24	2770.92	
	Humidity and temperature sensors				Reused
Claw	Pneumatic cylinders	6000.00	0	6000.00	
	Acrylic	Market	Value	100.00	Donation
	Vex Parts	Market	Value	500.00	Donation
Servos	Servos				Reused
Camera	Cameras				Reused
	Putty	280.00	0	280.00	
	Epoxy	1000.00	0	1000.00	
Propulsion	Seabotix Thrusters				Reused
	Bilge Pumps				Reused
Other supplies	Nails, Nail box	515.00	0	515.00	
	Hinges	310.00	0	310.00	
	Acrylic (general use)	Market	Value	100.00	Donation
	ABS plastic (3D printing)	Market	Value	3000.00	Donation
	Misc. hardware (heat shrinks, zip ties)	1914.00	0	1914.00	
Travel expenses	Air fare, ground transport, hotel (12 people)			690000	Paid by team members

*New Taiwan Dollar

Total cost: 23503.07 NT
785.40 USD

Account Balance: 126496.93NT
4225.01 USD

Appendix

A: Standard Operating Procedure: Safety Checklist

Buoyancy System

- Two buoyancy tanks attached firmly to the ROV
- Check for cracks (especially connections between acrylic and PVC)
- Strap them onto the ROV and we're set.

Cameras

Prior to System Plug-in:

- Confirm teflon wrap integrity
- Check mount stability
- Examine if there are any cracks
- Double check the waterproofing connections
- See if there's water/moisture in the case

After System Plug-in:

- Check camera image - Upside down? Sideways?
- Tightly seal the casing onto the module
- Make sure no wires are crushed together / caught in the threads of the casing
- We're good to go!

After Missions

- Check camera for leaks
  - If there isn't a leak, cameras are set.
  - If there is a leak, try and find the source
- 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

Pre Checklist:

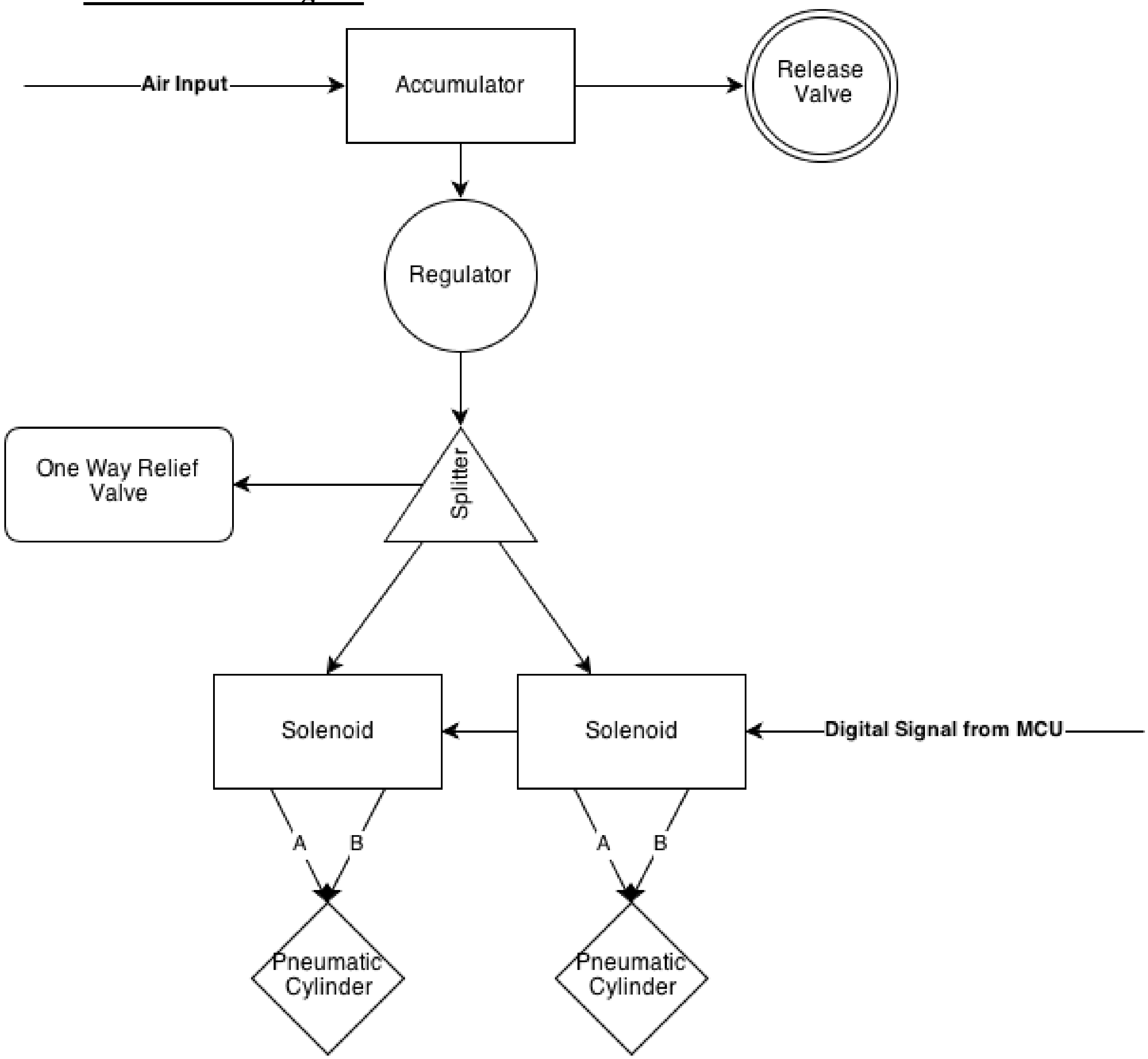
- Ensure the waterproof box is sealed tightly
- Double check Seacon connections to box
- Ensure there are no visible shorts or disconnections in the on shore and below shore control system.
- Ensure that the correct plugs are plugged in and that they are not flipped
- Check if fuse is still working

Post Checklist:

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

Date________ **Completed** ________________ **Verified by** ________________

A: Pneumatic Diagram



B: Props Checklist for Team/Progress organization

	Name	Started	Finished	Notes
Task 1:				
Backbone Interface Assembly (BIA):	ROV people	v	v	need more 45 degree joints
Science Interface Assembly (SIA):	Kevin	v	v	
Cable Termination Assembly:	Annette/EmS	v	v	
CTA bulkhead connector:	Emily	v	v	
Elevator:	Kevin	v	v	
Ocean Bottom Seismometer (OBS):	Em/Edmund	v	v	
OBS cable connector:	Emily	v	v	needs 14 m of 1/8 in. nylon rope
Designated area for OBS deployment:	Kevin	v	v	
Task 2:				
Hydrothermal Vent:	Em/Ed	v	v	bucket from Mr. Fagen
and probe (one step):	XiaoYang	v	v	
Task 3				
Mooring platform:	Annette	v	v	U bolts have been bought
Handle and locking mechanism:	Annette	v	v	
and Grab points (two steps):	Annette	v	v	need screw eye and screw hook
ADCP:	Em/Edmund	v	v	needs 3 in. endcap, U bolt
ADCP cradle:	Em/Edmund	v	v	
Connector:	Emily	v	v	
Bulkhead connector:	Emily	v	v	
Flotation and Ballast:	Mark	v	v	pool noodles
Task 4:				
Biofouling organisms:	Em/Ed	v	v	

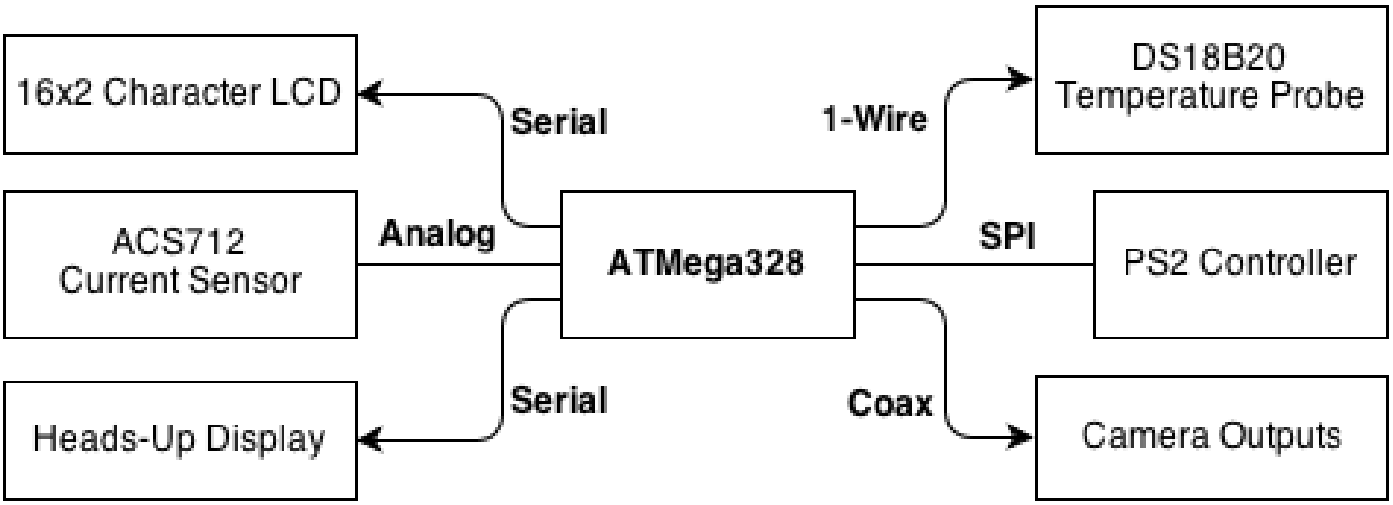
C: Development Schedule

TS-04 Development Schedule

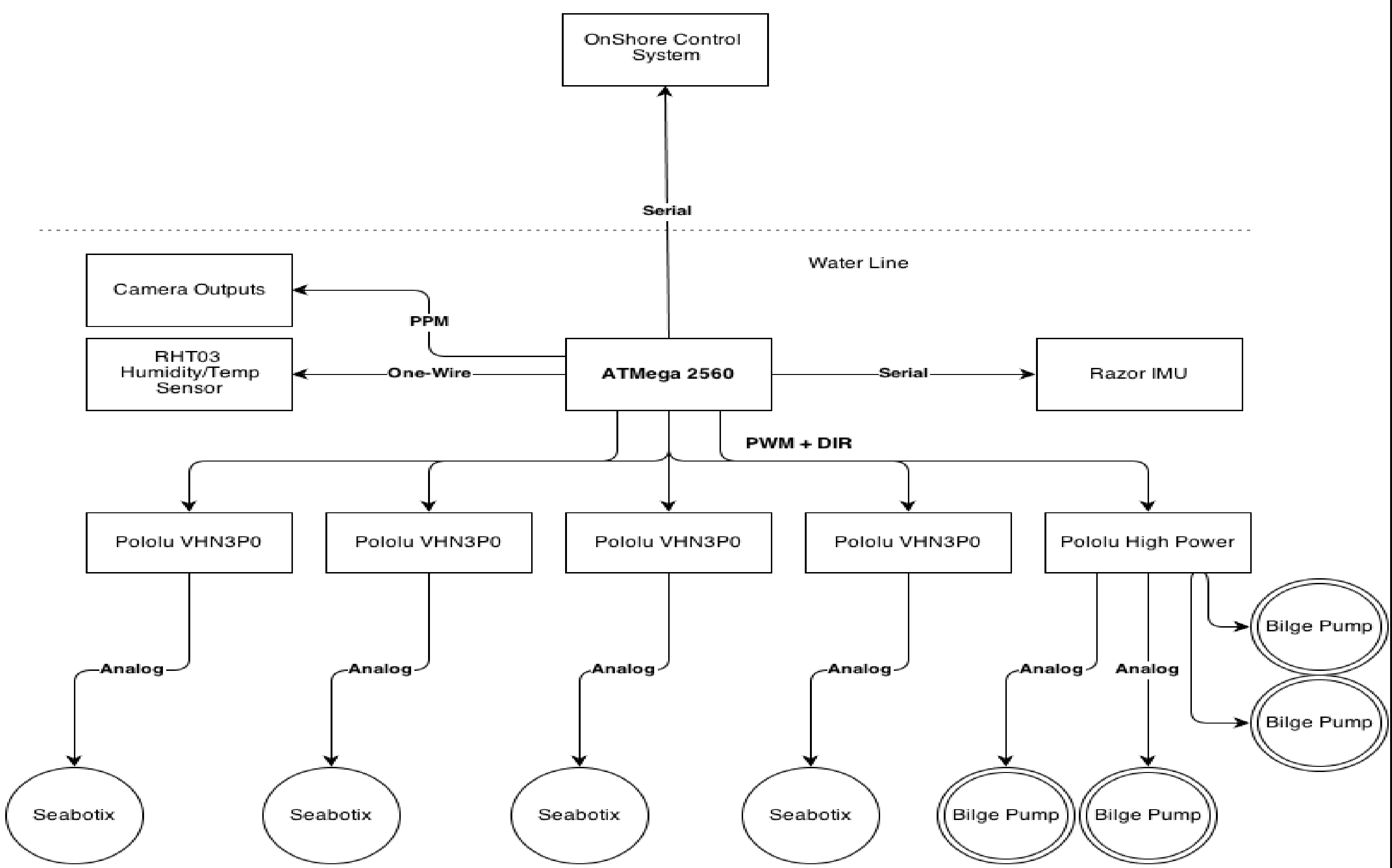
	ID	Project Manager	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	1	Anthony, Gregory	Initial Design + Feasibility																						
	2	Alvin	Reusability Evaluation																						
	3	Annette	Procure Parts																						
	4	Anthony	Waterproof Box Design + Construction																						
Phase 1	5	Anthony	Control System Design + Implementation																						
	6	Jin Suh	ROV Frame Design																						
	7	Young	Manipulator/Claw Design + Construction																						
	8	Jin Suh	Propulsion Casing Design																						
	9	Kevin, Gregory	Camera Construction																						
	10	Gregory	System Integration																						
	11	Emily H	Phase I testing																						
	12	Anthony, Greg	Reevaluation																						
	13	Young	Manipulator Reconstruction																						
	14	Anthony	Implementing temperature, humidity sensor																						
	15	Gregory	Backup Camera Construction																						
Phase 2	16	Emily S	Ensure Safety Guidelines Are Met																						
	17	Annette, Mark	Tech Report																						
	19	Emily H	Phase 2 testing																						
	20	Anthony, Greg	Reevaluation, Finalize Design																						
	21	Young	R&D New Claw																						
	22	Joey	Mission Testing																						
Phase 3	23	Anthony, Xiao Yang	R&D New Waterproof box																						
	24	Anthony, Xiao Yang	R&D Control System Interface																						
	25	Annette	Manufacture Backup Parts																						
	26	Emily S, Kevin	Pack for Seattle																						

D: System Block Diagram

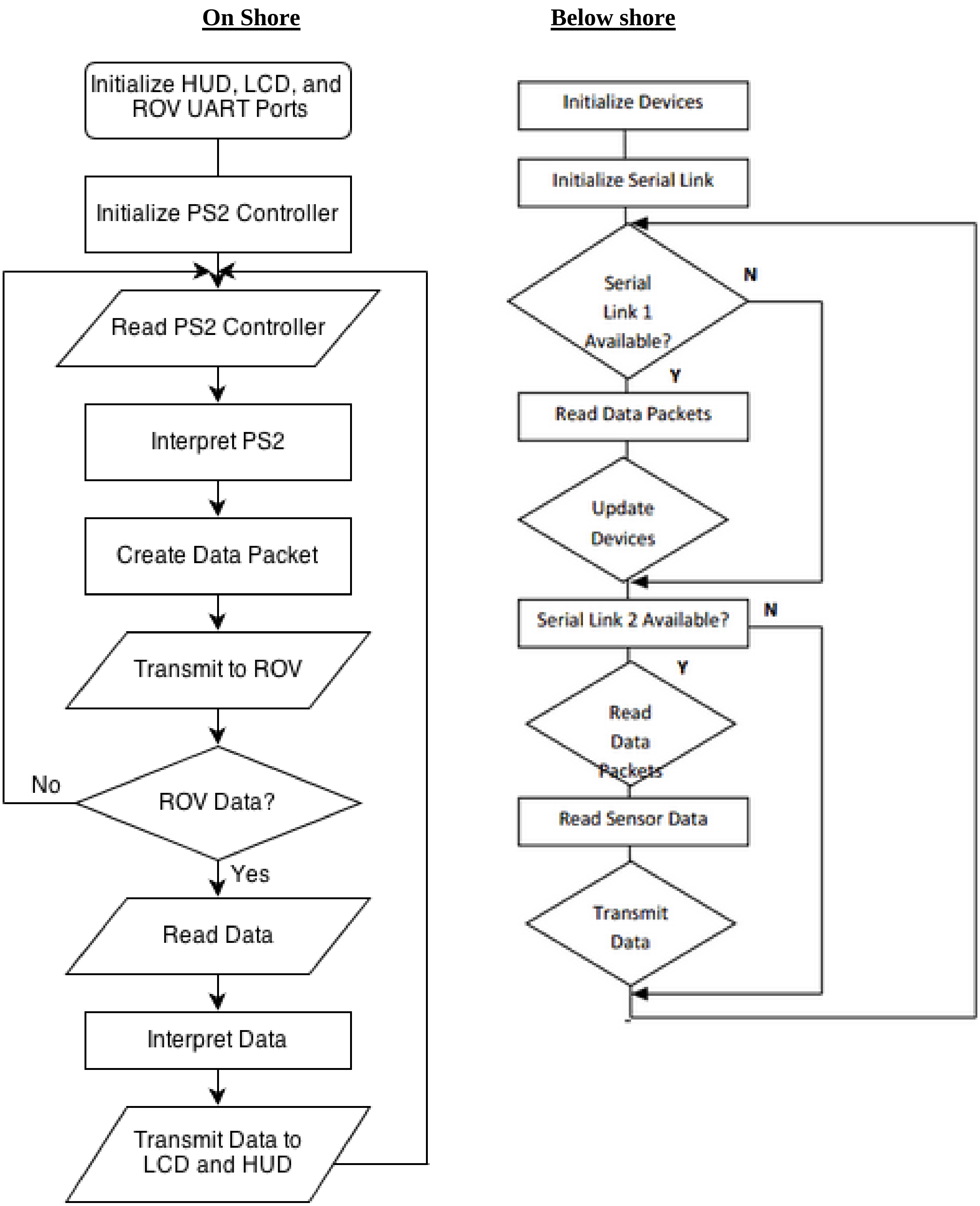
On shore:



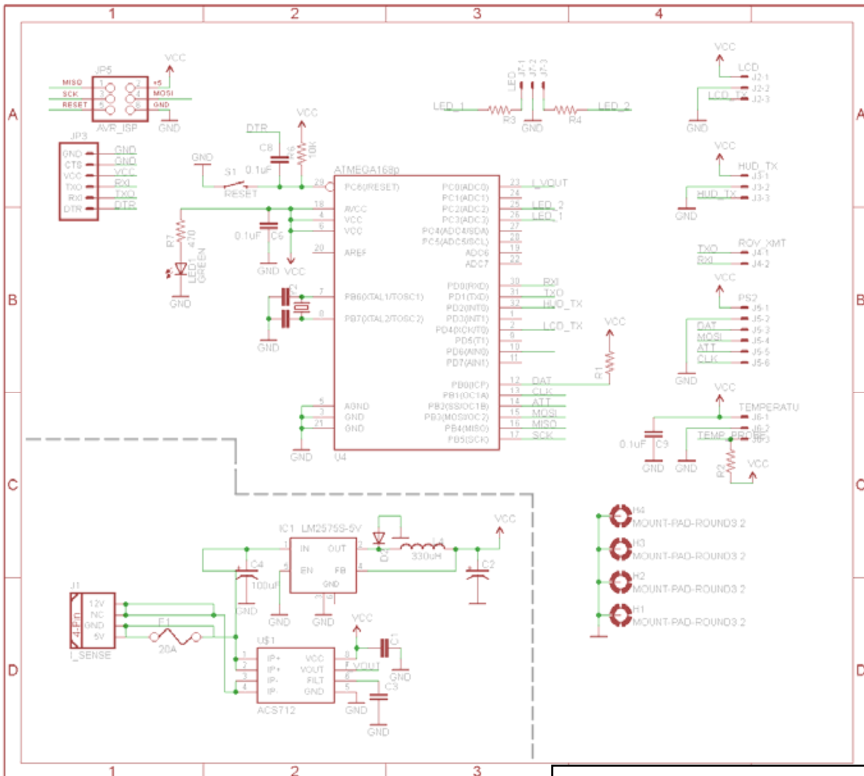
Below Shore:



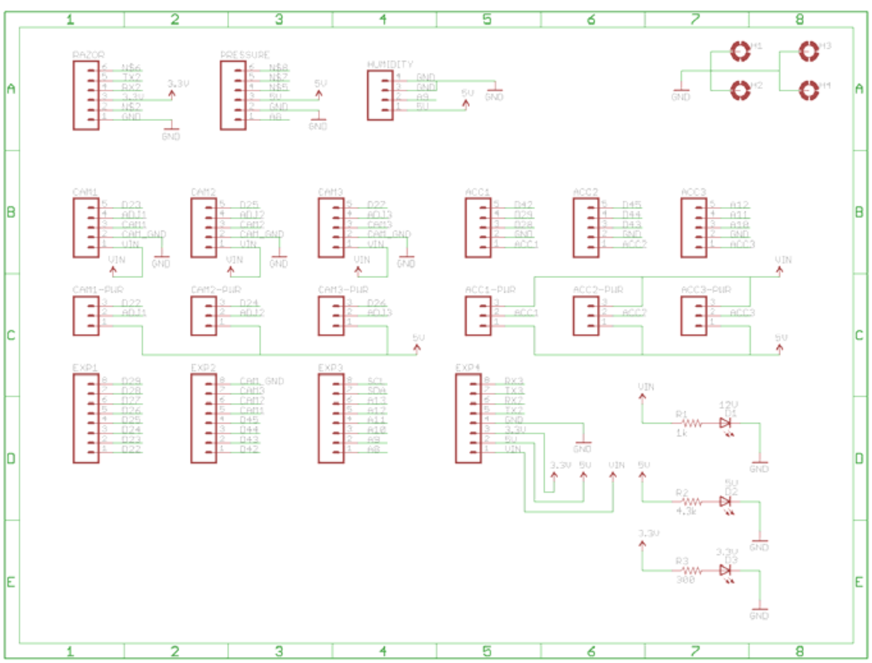
E: Software Flow Chart



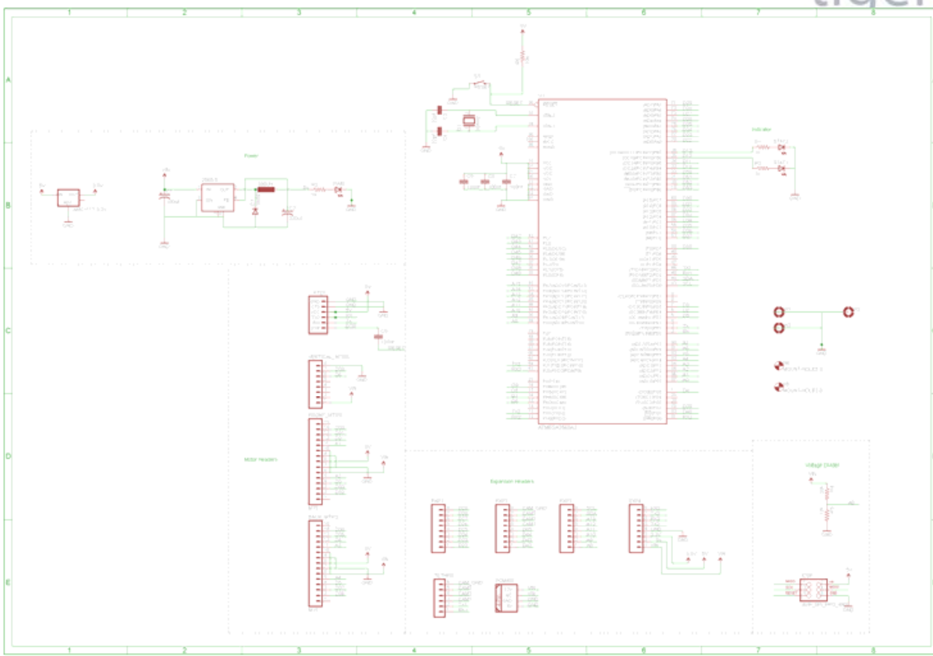
F: Electrical schematics



On-Shore Control System



Underwater Expansion



Underwater Control System

G: Electrical drawings

Underwater Control System