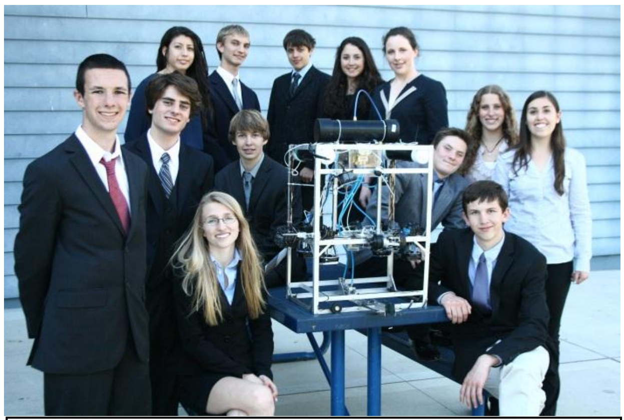
Aptos Mariners Robotics, LLC.

Aptos High School • Aptos, CA 95003

*Featuring: “**The Kraken**”*



Aptos Mariner Robotics LLC Team

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CEO, Pilot, Director of Software

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Director of Mechanical Engineering

Kayla Zoliniak – Senior, 2nd Year
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ABSTRACT

Aptos Mariner Robotics LLC produces underwater Remotely Operated Vehicles specifically built to meet customer requirements. Our most recent project is The Kraken, a deep-water ROV particularly suited to maintaining ocean observing systems. Such observing systems are critical to understanding how to preserve the ocean's vital resources.

Key features of The Kraken include: a robust frame equipped with powerful thrusters, an active ballast, cameras providing multiple views, a proprietary Magnetic Transfer Device/payload bay, and a general-purpose manipulator. These features enable The Kraken to install, operate, and maintain regional cabled ocean observing systems. Aptos Mariner Robotics LLC is dedicated to excellence in serving our clients and the environment.

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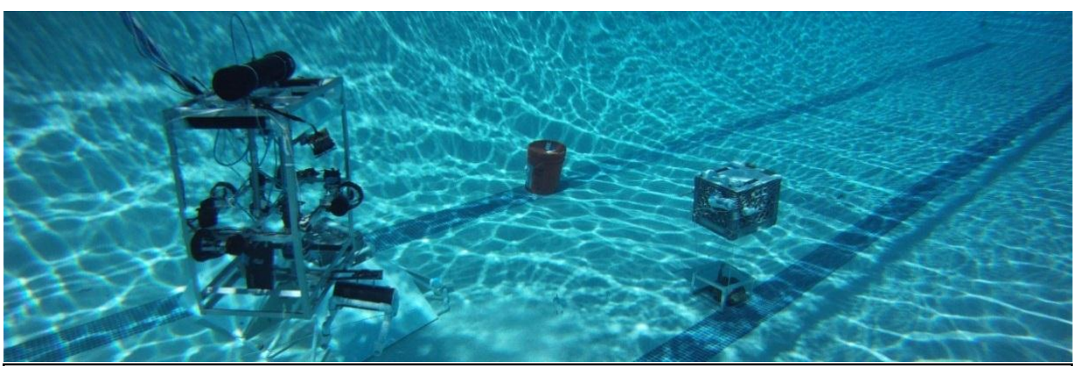


The Kraken in action

Operations

Safety

At Aptos Mariner Robotics LLC we strive to uphold the highest standards of safety for the ROV, the operators, and the environment. Our philosophy is demonstrated by the use of the partner system and the rigorous training we provide our personnel. The partner system requires anyone using machinery to have another knowledgeable team member act as a spotter by watching for hazards. Before the ROV mission specs were released, the team had a month and a half of training, which included teaching proper usage and safety procedures of machines and tools. Furthermore, Aptos Mariner Robotics enforces a dress code requiring close toed shoes, protective eye wear, and long hair tied back. When operating the ROV, we adhere to a policy that requires the pilot to call out before testing motors to ensure that our deck crews' hands are clear. We also check that the pneumatic pump's pressure is no higher than 40 psi before attaching it to the ROV.

Along with policies that the team follows in order to maximize safety, there are multiple safety features on the ROV itself. Several of these safety measures include shrouds and hazard labels on our motors, sanded edges on the ROV, and a 25-amp fuse attached to the lead of the electrical box. To ensure minimal impact on delicate ocean ecosystems, The Kraken is designed to return all mission tools and equipment to the surface.

*See appendix for Safety Checklist

Finances

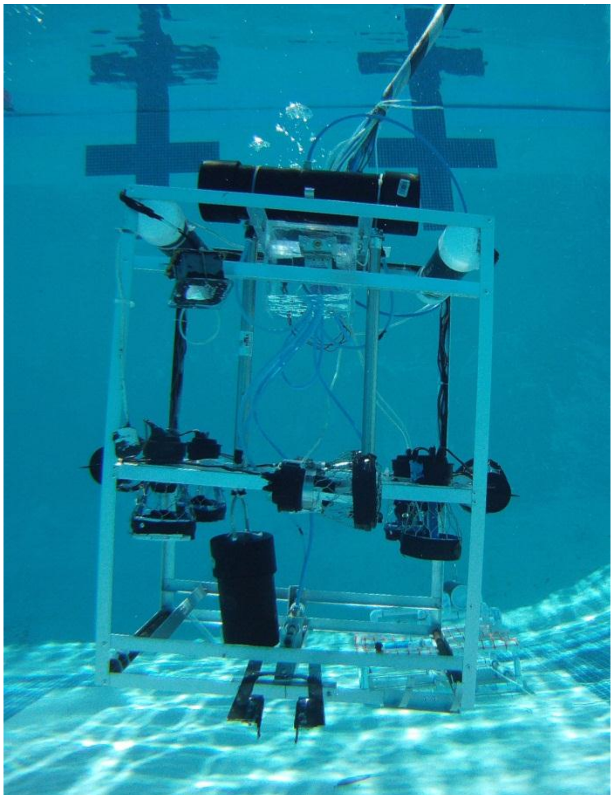
Category	Description	Budgetary Estimates	Actual Cost
Mission Props	PVC Parts	$160	$134.54
	J-Bolts, Screw Hooks	$30	$33.83
	Acrylic Sheets	$100	$104.91
ROV Structure	Aluminum Angle	$50	$49.95
	Buoyancy Materials	$100	$118.90
	Rivets	$20	$15.68
	Zip Ties	$20	$32.20
	Misc. Construction Materials	$75	$26.52
Pneumatics	Pipe Fittings	$20	$7.12*
	Solenoids	$200	$174.74
	Cylinders	$170	$150.50
	Pneumatic Tubing	$30	Donated

Propulsion	Bilge Pump Motors and Replacements	$350	$380.00
	Motor Shrouds	$25	Donated
	Motor Screws	$10	$6.89
	Use of Lathe	$20	Donated
Control System	Motor Control Boards	$400	Reused
	Wires	$100	Reused
	Misc Electronic Parts	$45	$43.98
Sensors	Board Cameras	$200	$124.00*
	Black and White Security Cameras	$20	Donated
	Materials for Camera Waterproofing	$30	$20
	Temperature Sensor and its Arduino Board	$85	$65.99
Misc Supplies	Poster Board	$75	$79.60
	Business Cards	$25	$21.00
	T-Shirts	$450	$396.12
	Food for Meetings	$150	$108.25
*Indicates Partial Donation or re-use of some of the components		**$2960**	**$2094.72**

Date Acquired	Income	Amount	Balance
10/3/2012	Watsonville Rotary Endowment	$175	-$1919.72
11/26/2012	Intuitive Surgical	$1000	-$919.72
2/14/2013	Santa Cruz Beach Boardwalk	$100	-$819.72
3/15/2013	Club Carnival	$293	-$526.72
3/26/2013	GoPro Sales	$220	-$306.72
3/26/2013	Aldina Real Estate	$250	-$56.72
3/26/2013	Costal Nursery	$250	$193.28
3/26/2013	Lassen Farms	$250	$443.28
3/22/2013	Slatter Construction	$100	$543.28
3/27/2013	Island Stone North America	$300	$843.28
3/27/2013	Alice B. Harper	$100	$943.28
3/27/2013	Russo's Collision Repair	$250	$1193.28
4/13/2013	Heppner Family	$100	$1293.28
4/2/2013	Watsonville Coast Produce	$100	$1393.28
4/8/2013	Gregory Beuerlein	$250	$1643.28
4/10/2013	Paul A. Koenig	$195	$1838.28
4/5/2013	Donut Sales at Car Show	$22	$1860.28
5/5/2013	Corralitos Market Sausages	$345.33	$2205.61
		$4300	**$2205.61**

Chassis Design Rationale

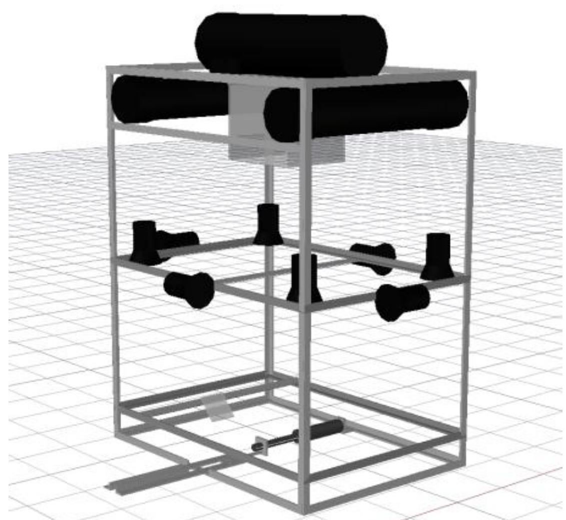
Frame



The Kracken with ADCP aboard

Our frame is designed around the tools necessary to complete the mission. We started with a sketch and realized that our ROV needs to be very tall in order fit it the Magnetic Transfer Device (MTD) with the Acoustic Doppler Current Profiler (ADCP) attached. One design goal is that the ADCP be completely contained during the transfer phase of the mission, yet easily deployed in the mooring platform. To achieve the necessary reach, we selected cylinders with a 30 cm throw and overall length of 38 cm, resulting in a minimum ROV height of 66 cm (allowing for the MTDs 2 cm exposure beyond the bottom of the frame). The width of the ROV is set at 50 cm based on the space needed for ADCP storage and propulsion motors. The 37 cm length of the ROV is determined by the dimensions of the claw which is 34 cm long inside the frame.

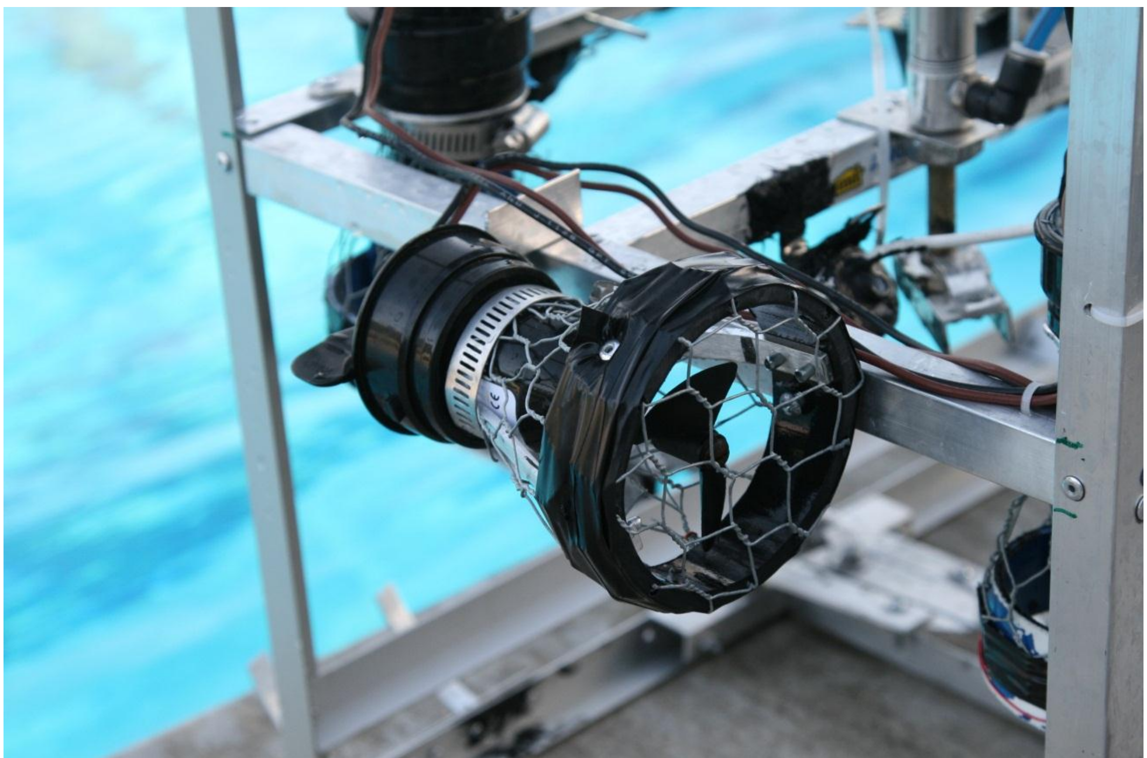
The frame is constructed from 1/16" x 1/2" aluminum angle, which is strong and lightweight. The frame was assembled using pulled aluminum rivets (pop-rivets). For strength and rigidity, two rivets are installed for every contact point. In each corner there are gussets to provide additional structural rigidity and make the ROV even more durable.



AutoCAD frame model

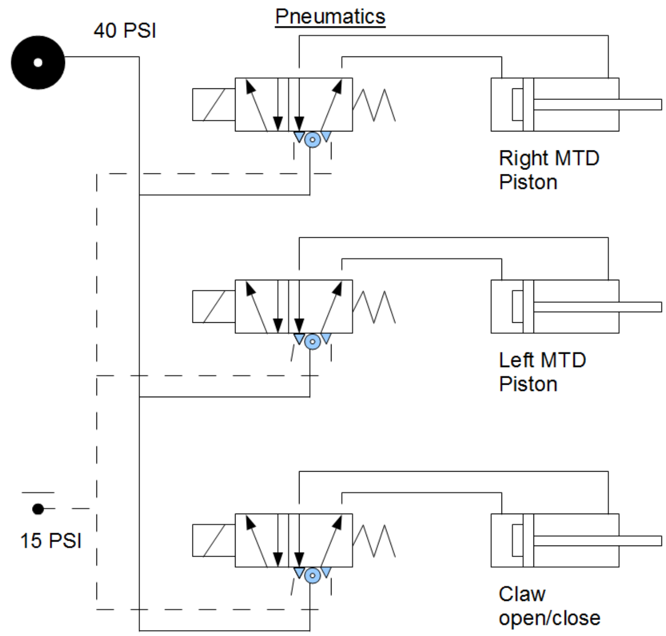
PROPULSION

The Kraken is equipped with eight Johnson bilge pump motors, each drawing 3 amps as installed. These motors are ideal because they come waterproofed and do not exceed the power limit. Four vertical motors are positioned inside the robot providing effective up and down movement. There are also four lateral motors, one fore, one aft, and one on each side. The positioning of the motors prevents obstructions and allows the maximum torque between the motors to rotate the ROV. The motors supply our robot with the ability to quickly and efficiently change directions without having to turn to face the desired direction. Each motor is equipped with a custom motor shroud and cage. The motor shrouds not only protect the motors and equipment, they also help attach the motors to the frame. The motor cages fastened to the shrouds prevent small objects such as cables or organisms from becoming caught in the motors.



Port side thruster with protective shroud and cage

Pneumatics



The Kraken employs pneumatics to activate its manipulator arm, Magnetic Transfer Device (MTD), and our active buoyancy system. On the surface, an air compressor supplies 40 psi which allows us to actuate three separate pistons on the ROV while simultaneously controlling our buoyancy. We run a 15 psi back pressure, providing a 25 psi differential pressure which keeps the pistons' interiors pressurized at all times. The needed back pressure was calculated knowing we would need our minimum pressure to be greater than the water pressure exerted at the maximum depth.

$$P=r*g*h = (1\ g/cm^3)(32\ ft/s^2)(30\ ft) = (1000 kg/m^3)(9.8\ m/s^2)(9.144\ m) = 89.61\ kPa$$

This converts to 13 psi, which we rounded up to 15 psi to prevent water intrusion, enhancing the effectiveness and longevity of the pistons. Our pneumatic lines are routed to a manual control switch for our active ballast and three of our five-way two-position solenoids.[1] Each of the three solenoids controls one of the three on-board pistons. Two pistons[2] make up the MTD, while the other[3] actuates a manipulator arm.

To improve long term reliability as compared to previous years, the Kraken's solenoids are mounted in the top of a custom fabricated acrylic dry box, open only at the bottom. As the pneumatics are used, the discharged air is released into this box, keeping the solenoids dry. When activated by our control system, the solenoids reroute the air flow to actuate our pistons. Our active ballast is controlled manually.

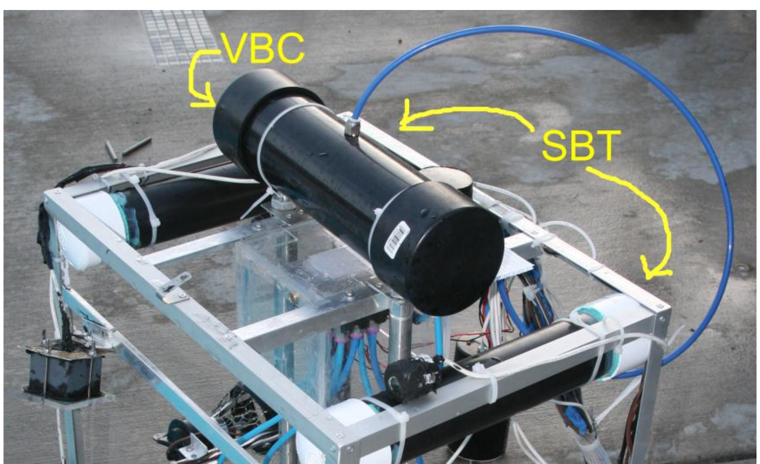
Pneumatic solenoids mounted in dry box

ACTIVE BUOYANCY

Based on the mission requirement to carry heavy loads, including the SIA, we designed an active buoyancy control system which consisted of a constantly flooding chamber into which we would periodically pump air to achieve a given flow rate. Originally, we were going to control the system using our electric solenoids. They have no “off” position, so we experimented with turning them rapidly on and off to match a permanent slow air leak. We found this hard to control and were concerned that the constant bubbles could interfere with mission operations.

The Kraken is thus equipped with a manual 3 position buoyancy control valve that allows us to add, remove, or hold constant the volume of air in the chamber. This design is superior to our previous iteration. It is more stable, not requiring matched flow rates to maintain a constant depth, and it can respond more quickly to diving commands. It also proved less expensive to construct.

The buoyancy system is centered around our twin 34 cm long 2” PVC Static Buoyancy Tanks, or SBT’s, and our 35 cm 3” PVC Variable Buoyancy Chamber, or VBC. The VBC was based off of the active buoyancy system that we observed in use on an Ocean Gate’s submarine Antipodes. The V.B.C. is powered by a pneumatic air-hose that pumps in air through the roof of the chamber and is fitted with wrappings of Teflon tape in the connection to prevent air from escaping. The chamber is controlled by a three-position valve which allows us to add air, stop all air flow, or remove air which floods the tank through open vents along the bottom of the chamber. With the combined volume of the VBC, and the SBT, there is a range of 1300 - 2900 cubic centimeters of buoyancy. This system has been positioned at the top of The Kraken for a high center of buoyancy.

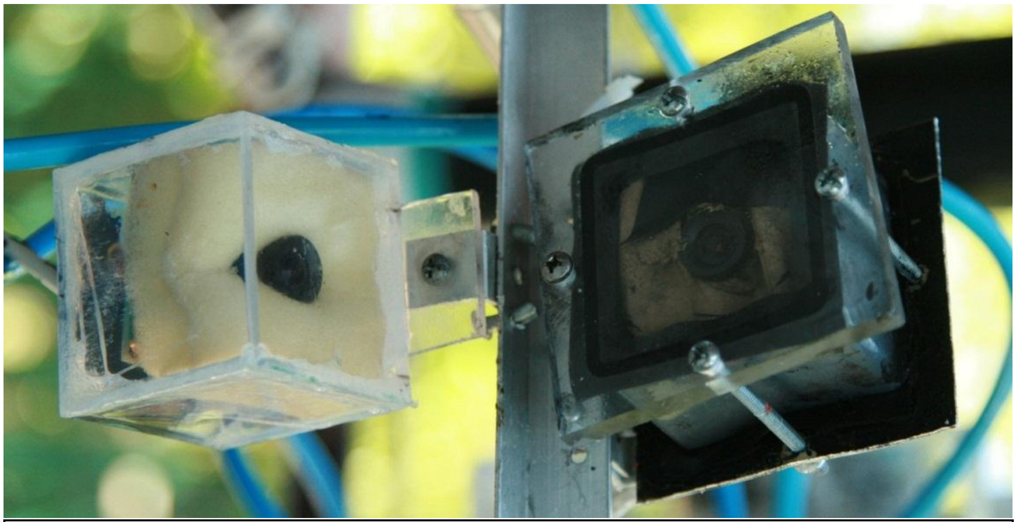


Buoyancy control system

The ballast rods and mission tools positioned at the bottom of the Kraken yield a low center of mass. This layout ensures high stability, fast vertical movement, and neutral buoyancy even while carrying or operating multiple pieces of equipment, such as the Scientific Interface Assembly and the Acoustic Doppler Current Profiler.

Command and Control

Cameras



Navigation (left) and MTD docking (right) water proofed cameras

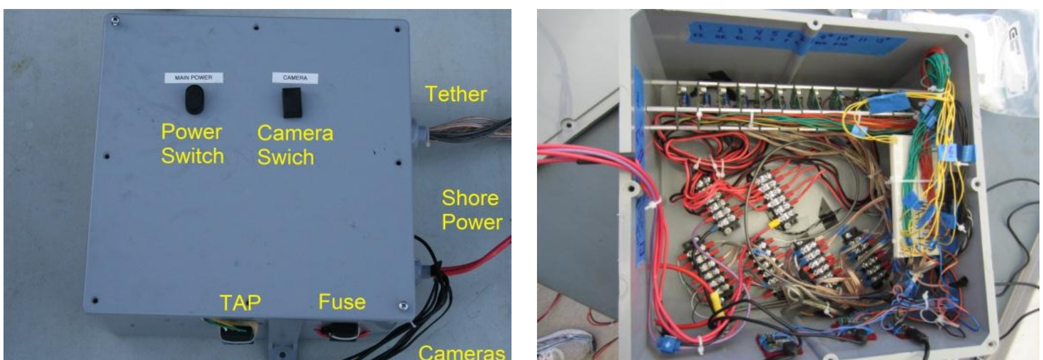
In order to successfully navigate and use its onboard equipment, the Kraken is outfitted with three Talos MC100 Color Board Cameras and three security cameras. Board cameras, used for navigating our ROV, are useful in dealing with this year's mission, which includes handling components from a damaged observing system which have been scattered on the ocean floor. Their wide field of vision (92 degrees) allows us to quickly identify and maneuver the Kraken to the object. One board camera is mounted in the middle of the ROV, facing the bow. This allows the camera to be both the main navigational camera and the claw viewer. Another is attached to the front upper right corner of the ROV, pointing down. This second board camera gives another perspective view of our claw, permitting quick pick up and manipulation of objects on the sea floor. The third board camera is in the middle of the ROV, pointing downward, giving a full view of the two "down pistons." In addition to having a wide angle lens, these cameras come with automatic gain control, which cancels out the glare from light hitting highly reflective surfaces - a hindrance on our 2012 ROV model.

To protect the board cameras from water, Aptos Mariner Robotics LLC considered and tested two new camera enclosures. The design of the first camera case involves a frame of square PVC piping with rubber gaskets on each end; the PVC piping is held tightly between a metal square at one end and a plastic square on the other, the rubber creating a water tight seal. In our alternative camera case, we enclosed a board camera in an epoxy-sealed clear plastic golf ball holder. In the interest of long term reliability, during this prototype phase, we continue to use and observe both designs that, so far, have been equally successful and are cleared for production. We placed a silica gel pack inside each design with the camera to protect the camera from trapped moisture in the enclosure.

In comparison to the board cameras, the three security cameras have a narrow view and are less expensive. These allow the Kraken to have additional views with little added monetary cost or weight. These support cameras are used as backup in the event that the main cameras malfunction. Using the camera case as a mold, we enclosed the cameras in epoxy to protect the wires and the lens from water.

Electrical and Electronics

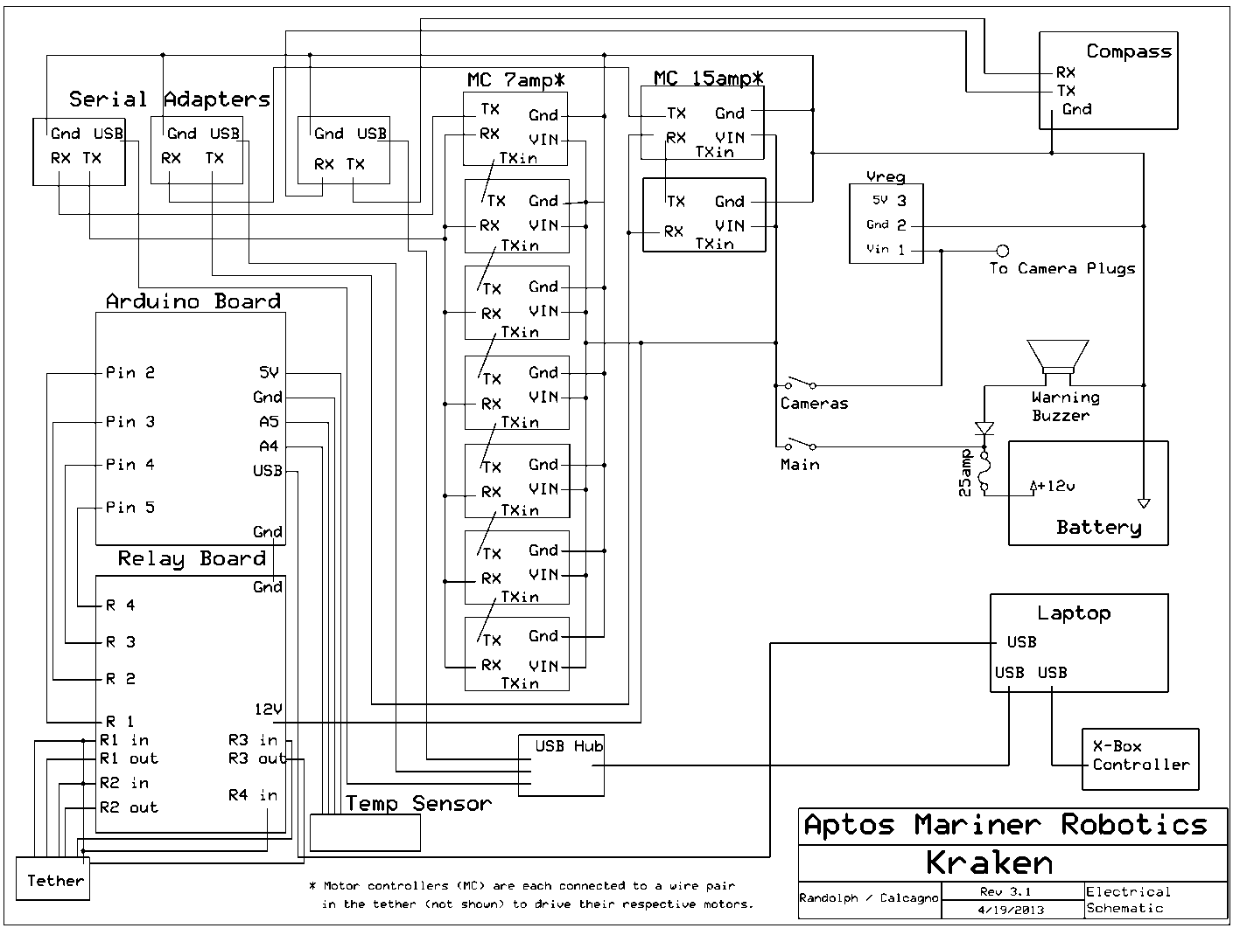
An important goal for Aptos Robotics, LLC has been the development of a flexible control box that is more reliable and more easily maintained than our competitors' products. With the Kraken, our investment has paid off as we have been able to reuse proven hardware and focus on mission adaptation and achieve higher reliability.



The control box exterior (left) and interior (right)

The heart of our control system is a water resistant box 15 cm tall with a layout area of 30 cm^2. In our box, the motor controller stack and terminal boards are angled so there is less tension on the connectors and greater bending radii on the wires. Our extra motor controller boards can be quickly and easily utilized due to our use of a bread-board for the communications daisy chain. Our motor controllers are split onto two separate USB to serial adaptors - the two up/down controllers (Pololu simple motor controller – fifteen amp) are connected to their own adaptor, as are the four lateral controllers (Pololu simple motor controller - seven amp). Separating these has increased the reliability of our equipment and its capacity to communicate with its companion software.

The first element in the control box power circuit is the fuse, which ensures excessive current cannot inadvertently be drawn. Next are the power switches - the first for main power and the second for cameras. After that, current runs to the terminal blocks for power distribution. One is for power in and the other serves as the grounding or power out. From these blocks, power is distributed to the motor controllers then continues to the terminal blocks that anchor the tether.



We use 10 gauge wire for our primary battery lead (from the battery to the box), transitioning to fourteen gauge wire for the main power distribution inside the box (connections to the switches and motor controllers). Our use of thick wire for main power prevents excessive loss of voltage at high currents. From the motor controllers and USB adaptors, smaller, 22 gauge wire serves the purpose of signaling between the motors and the computer and has the double advantage of being lower cost and taking up less space within the box.

To the core box, we have added an auxiliary Tether Access Port (TAP). This exposes 12V power and several tether leads allowing optional secondary electronics to operate mission specific equipment on the ROV. This has given us the option to control our electro-magnet and pneumatic solenoids via the off board Arduino[5] package, thereby reducing the number of required motor controllers. This increases responsiveness of motors, although we have limited power available on the Arduino board to operate the necessary relays. Future iterations will add an additional voltage regulator, paving the way for further innovation.

Software

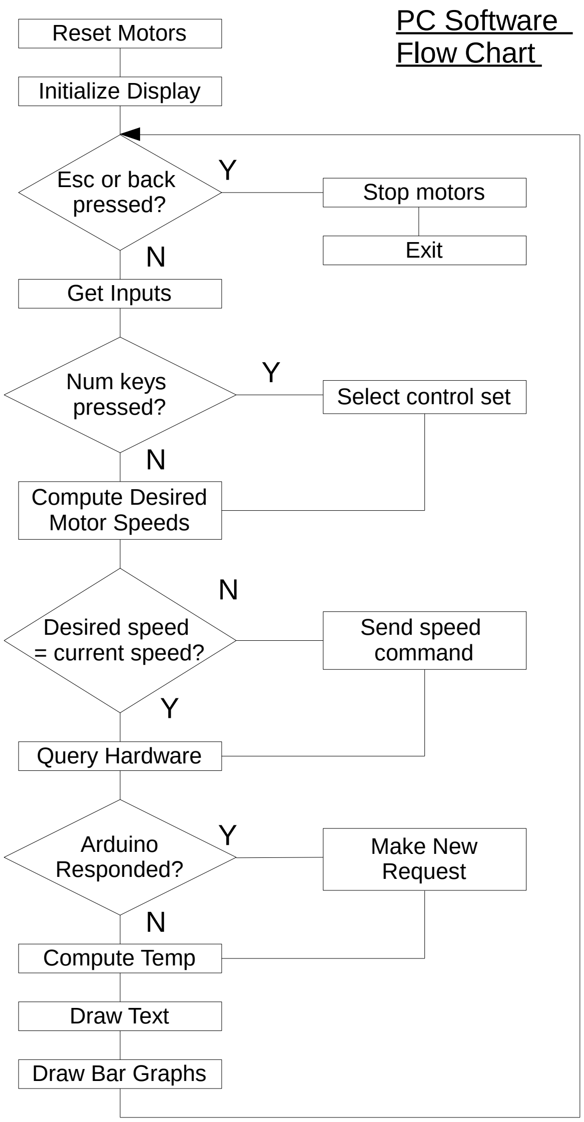
Efficient mission performance requires the pilot have precise control of the ROV at all times and in all operating conditions. A software control system is essential to recognize and interpret the pilot's intentions as expressed through the input system, and apply the appropriate commands to the ROV motors and mission tools.

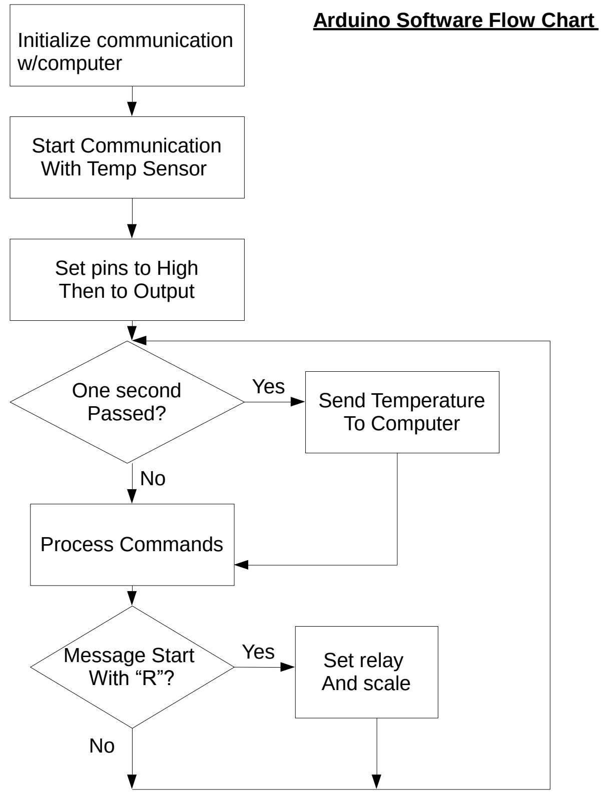
Xbox Controller

Operation of our ROV is accomplished using the Xbox controller which provides a pair of analog joy sticks, and several buttons. Basic navigation is accomplished through manipulation of the sticks, while operation of payload tools such as the claw and MTD are controlled via the 'A,B,X,Y' buttons and D-pad.

Our software also provides payload and sensor control. We operate our pneumatic system via electrically controlled solenoids whose state is displayed graphically on the software display and controlled via the controller buttons. We extended our existing serial communications code so that it could support the Pololu motor control protocol, the optional electronic compass protocol, and a new proprietary protocol to interoperate with our Arduino temperature sensor and auxiliary control module. We have a base class that handles serial I/O and set of derived classes which add the specific bytes allowing them to communicate with the different pieces of hardware. Responses from the electronics are received immediately from the motor controllers via blocking I/O calls, and asynchronously for the compass and Arduino.

The Arduino is listening for commands as well as spontaneously sending temperature data to our laptop based control software once per second. Although the Arduino is constantly taking continuous temperature measurements and listening for commands, it sends the most recent value only once per second to avoid overloading the PC and causing lag while still giving us an accurate and timely reading.





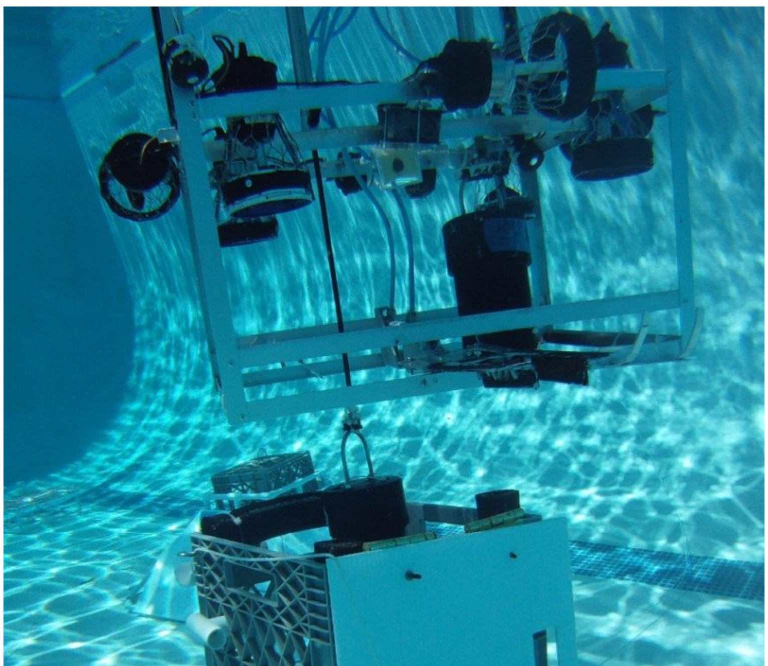
The main structure of the ROV control software is a continuous loop. It queries the Xbox controller state, and determines both the current state of the controls and, importantly, what has changed since the last update. The new input data is run through the control logic via an interface that allows us to dynamically change control sets. The current control set turns the input state into commands to be sent to the ROV.

The commands are then sent to the ROV via our serial port wrapper objects which handle the hardware protocols. Then the hardware state is optionally queried and inspected for errors. Finally the commands and hardware state are displayed for the operator on the screen in the form of bar graphs and several lines of text. This output aids in situational awareness during normal operations and is essential when troubleshooting problems during development.

Mission Tools

Magnetic Transfer Device (MTD)

Our Magnetic Transfer Device is designed to quickly and efficiently transpose the position of the two Acoustic Doppler Current Profilers (ADCPs). The device consists of two pistons,[2] each with a ¾ inch bore, 12 inch stroke. Powerful neodymium magnets are attached to the end of each piston. One of these is encased within a thin metal sheath which then screws onto the end of the piston. The other magnet is fastened to its piston by a web of interlocking cable ties. This is thin enough so the magnetic field easily penetrates and it allows the magnet's position to be flexible. This allows the magnet to rotate to the side while holding the ADCP so that we may load the ADCP before deploying the ROV without the ADCP extending out past the bottom of the Kraken.



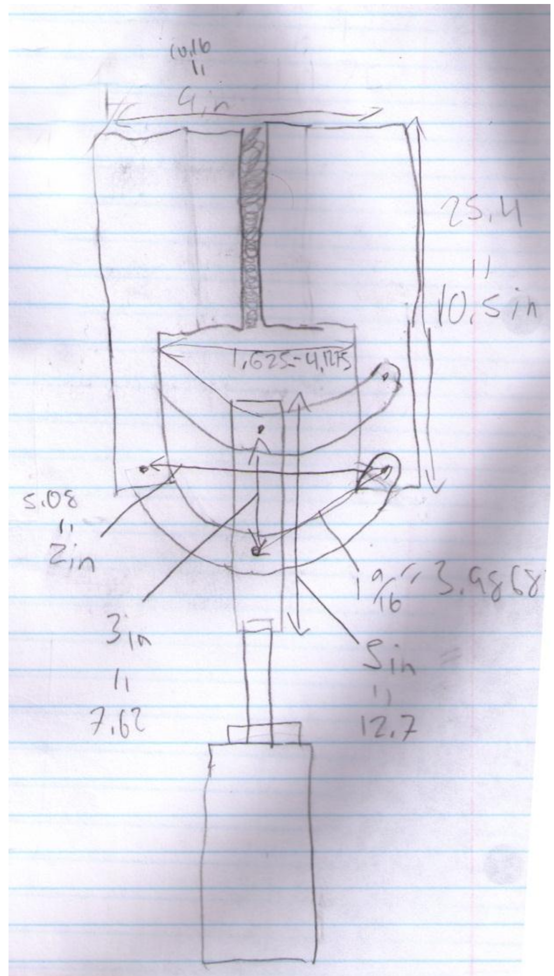
The MTD in action

The starboard piston is able to collect the ADCP from the mooring platform, while the port side piston is equipped with a sheet of acrylic plastic which allows the robot to deposit the new ADCP in the mooring platform. The plastic sheet serves as a one-way door: slanted downwards to allow the ADCP to slide past it during the deposit stage, but ensuring that the ADCP remains deployed while the piston is retracted.

MANIPULATOR (THE CLAW)

When designing the claw, we considered the tasks the claw needed to accomplish and the qualities necessary to accomplish them. In order to work alongside the mooring platform, and within the backbone interface assembly (BIA), the claw had to be engineered to be long and narrow. A large surface area was important to provide a secure grip. Sketching claws with different shapes and movements, we arrived at our current design: a claw that has straight arms, operates in linear movement, and is powered by a piston.

With the design of the claw complete, we made cardboard templates of the arms, center shaft, and connectors and traced them onto metal to allow us to cut accurately on the band-saw and chop-saw. These pieces were then smoothed using the grinder before being drilled for the screws and rivets. After we had the main pieces assembled, we cut aluminum angle to make up the gripping surface and riveted it in place.



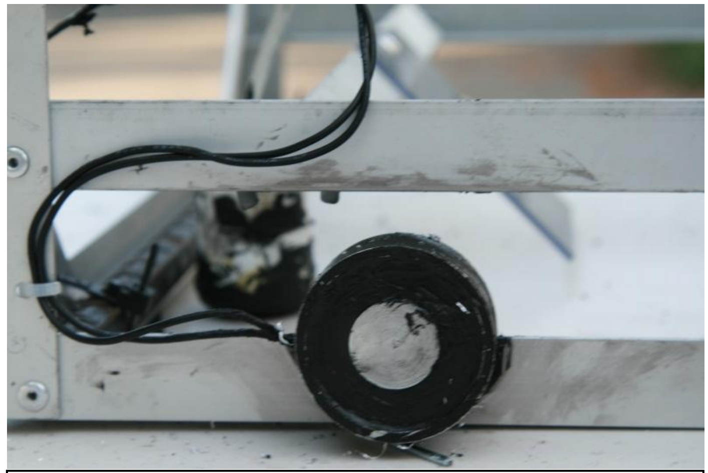
Early construction drawing

A variety of materials were used to manufacture the claw in order to give it optimum performance. .060 aluminum sheet was used for the center-shaft, main bodies of the arms, and connectors between the arms. 1 inch and ½ inch aluminum angle, rubber, and scrubby sponge was used to make the grippers attached to the arms. To power the claw we used a one inch diameter piston[2] with a two inch throw.

Many skills were required to create and assemble the claw. For example, we learned how to communicate our ideas and combine them to create the best possible product. We also learned basic mechanical skills such as riveting with pop-rivets, using tin-snips, and using a hand drill. Finally, we learned more complex skills such as operating the band-saw, chop-saw, grinder, and drill-press.

Electromagnet

The Kraken is equipped with a powerful electromagnet recovered from a gate latch. This electromagnet can lift up to 9 kg and only requires .67 amps. Since most of our mission objectives incorporate ferrous metal, the magnet can serve as a backup for the main claw when things need to be picked up or moved.



Electro magnet attached to the frame

Trident Payload Mount

The Trident

On The Kraken, two prongs are attached to enable us to carry the scientific interface assembly (SIA) down from the surface and insert it into the backbone interface assembly (BIA). The trident can also help open doors on the BIA and the mooring platform. This is convenient because it allows the claw to engage in other tasks, such as transporting the temp sensor, or holding the cable termination assembly (CTA). While the "trident" actually has only two prongs, we felt that "bident" sounded too much like dental cream.

DEPLOYABLE TEMPERATURE LOGGER

Temperature probe with field developed alignment basket

The temperature probe is a digital electronic thermometer mounted on an aluminum dowel and embedded in epoxy. Aluminum was used for the front of the probe because it has a very high thermal conductivity so it quickly transfers the heat of the vent to the probe. The epoxy was used because it provides water proofing and has low thermal conductivity and therefore will insulate the probe from the surrounding pool water to avoid interference with the accuracy of the readings.

The temperature sensor is a DS-1631 High-Precision Digital Thermometer and Thermostat[4]. We chose a digital sensor because it is more effective over a long wire than an analog temperature sensor due to noise interference from other wires. The output of the thermometer is read by an Arduino Uno[5] on the surface. Because we are working at the end of a 20m tether, we had to slow down the I2C communication between the Arduino and the temperature sensor. We did this because it will reduce noise from the wire not rising to the necessary voltage quickly enough. We also experimented with adding pull up resistors. While these did improve the shape we saw on the oscilloscope, they proved unnecessary once we slowed the I2C bus down to 500Hz.

To ensure the accuracy of the sensor, we assume standard temperature and pressure and calibrated the sensor in a bowl of ice water (0 degrees C) and a pot of boiling water (100 degrees C), then corrected the reading in the software using a linear equation of the form y = mx +b where x is the reported value and y is the calibrated temperature.

Arduino with payload control relays

Quality Assurance

Testing

Our project this year benefited from systematic testing during development. We tested everything before putting it all together on the actual ROV. When building the camera housing we tested multiple designs in order to figure out which design would function the best in keeping the cameras dry while providing a case that is easy to mount and provides a clear view.

For the claw we designed a prototype and observed how it worked and what material would work the best and the smoothest for our needs. We checked the motors by placing them in water and measuring the current drawn. While developing the MTD we tried a variety of magnets to find the proper strength and experimented with various methods of keeping the magnets attached to the pistons.

Checking electrical connections

Once all the systems were integrated, we also conducted extensive practice operations and development testing of the entire ROV in the mission environment. This operational testing allowed us to improve both our equipment and our technique, increasing reliability and driving down mission times.

Troubleshooting Techniques

An ROV is a complex machine where many things can go wrong. As we developed our ROV, we encountered many problems and we had to figure out the cause of these issues before we could solve them. Through this we developed a method of troubleshooting through process of elimination. For example, one technical challenge we faced was a failure of our pistons and claw to operate. We initially looked at the pneumatic solenoids. To test the solenoids, we pushed the buttons on them to manually trigger them. Had they not worked, we would have moved on to check that the air compressor was connected and functioning. Since the solenoids worked properly when tested manually, a problem with the pneumatic system was excluded and we moved on to check that the Arduino was properly powering the wires when requested. We found no signal from the relays when the computer sent its messages, so we checked the Arduino pins. We found no signal there either. At that point we recognized that the Arduino was not responding to messages at all. Through this process, we identified the cause of the issue was the Arduino crashing, so we rewired the box so as to not use the relays.

Retrospective

Lessons Learned

Our team has learned the importance of redundant systems and the need for interchangeable parts. The first iteration of a design often needs to undergo modifications. Our preferred design for the waterproofing of our cameras uses a gasket compressed between removable plates. This was valuable allowing us to access and resolder one of our cameras. We have also learned to build redundancy into our electrical control systems, keeping spare control boards and including a breadboard for quick modification. Finally, our manipulator is designed to be interchangeable, using only readily available and replaceable materials: rivets, nylon spacers, and aluminum angle.

The construction of an ROV naturally takes much of our time. An interpersonal skill we have gained is the ability to multitask in a group setting. Many times throughout the year, members of our team have been working together on our ROV on the eve of an important test. As many of us are in AP Classes, finding a solution to this time crunch was crucial. Those of us who share classes have learned to quiz each other while modifying the ROV in order to help prepare each other for upcoming tests.

Future Improvements

The Arduino device is a new component this year. As such, we have kept track of ideas by which we can improve the function and reliability of the Arduino. The most essential improvement for the Arduino device is providing it with an external power supply. It is currently reliant upon power via a USB cable from our laptop. This has proved insufficient at times, so we would like to ensure that our Arduino always has an adequate supply of electricity. We are also considering moving more of our controllers into our Arduino box, moving towards our future goal of having onboard electronics controlled by our Arduino.

Team Size Challenge

This year, Aptos Mariner LLC had the largest team yet. While we were excited to have new recruits, we had to establish systems to keep everyone productive. Our solution was to maintain a list of individual projects that needed to be done. Then, when an individual or a group of people were ready for a job, they could look at the list of unaccomplished tasks and create a team to undertake the assignment. This allowed team members to pick problems that they were interested in solving. This also allowed everyone to have an opportunity to lead a task force and carry out their ideas. We found that people become more focused and committed when they have a specific component of the ROV to work on. Through this easy sign up system, our company was able to utilize a large dedicated group productively.

Reflection

After a team discussion, we all agreed that working together with fellow innovators was one of the most beneficial parts of ROV this year. In the beginning, we were all a little nervous about our capabilities - it was the first year of Ranger for most of us and the first year in a leadership position for the rest. Nevertheless, after a short amount of time we became comfortable with each other and were able to express our ideas freely, without having to worry about being wrong. We have gained confidence in our opinions and are able to plan and carry out projects by ourselves without feeling lost. We all are confident in our soldering abilities as well as our abilities to use a drill, a band-saw and rivet gun. Our enthusiasm for science has greatly increased because we have had the experience of working together and building something new.

-Members of Aptos Mariners LLC

The Kraken assembly crew

ACKNOWLEDGEMENTS

Thank you to all who assisted in making Aptos Mariner Robotics LLC successful.

- MATE Center -- For making this event possible
- Jill Zande and Matt Gardener -- For coordinating these events
- Aptos High School -- For the use of the AHS pool
- Joseph Manildi, Teacher Coach -- Hosting our lunchtime meetings
- Scott Randolph, Mentor -- Opening his house and sharing his electrical knowledge
- Keith Jeske, Mentor -- Teaching us how to handle power tools
- Suzanne Randolph, Team Mom -- Having a warm dish or cold drink for the team
- Our Sponsors -- Whose donations made the construction of our ROV possible:
  Watsonville Rotary Endowment, Intuitive Surgical, Santa Cruz Beach Boardwalk, Aldina Real Estate, Costal Nursery, Lassen Farms, Slatter Construction, Island Stone North America, Russo's Collision Repair, Alice B. Harper, Heppner Family, Gregory Beuerlein, Watsonville Coast Produce, and Paul A. Koenig

REFERENCES

[1] Soleniod: http://www.automationdirect.com/adc/Shopping/Catalog/Pneumatic_Components/Pneumatic_Valves_-a-_Accessories/Solenoid_Air_Valves_-a-_Accessories/5-port_(4-way),_2-pos.,_Body_Ported_-z-_Manifold_(AVS-5,AM_Series)/AVS-5211-24D

[2] 12 inch Piston: http://www.automationdirect.com/adc/Shopping/Catalog/ Pneumatic Components/Pneumatic_Air_Cylinders/Round_Body_Air_Cylinders_(A-Series)/3-z-4_inch_Bore_with_Magnetic_Piston/A12120DP-M

[3] 4 inch Piston: http://www.automationdirect.com/adc/Shopping/Catalog/ Pneumatic_Components/Pneumatic_Air_Cylinders/Round_Body_Air_Cylinders_(A-Series)/1-1-z-16_inch_Bore_with_Magnetic_Piston/A17020DP-M

[4] Thermometer: http://www.maximintegrated.com/datasheet/index.mvp/id/3241

[5] Arduino: http://arduino.cc/en/Main/arduinoBoardUno

Appendix A: Development Schedule

	1-Oct to 18- Dec	18-Dec	18-Dec to 20-Jan	20-Jan to 27-Jan	27- Jan to 10-Feb	10-Feb to 10-Mar	10-Mar to 17- Mar	17-Mar to 22-Apr
Teach New Members to Use Electric Tools								
Practice Creating Structures Using Aluminum Angle								
Design and Build Camera Housings								
Competition Specs Released								
Begin Having Meetings Every Saturday								
Create the Mission Props								
Sketch and Design the Kraken								
Build Frame								
Solder Motors and Attach Housings								
Build Pneumatic Tools								
Attach Buoyancy								
Program Software								
Attach Pneumatic Tubing								
Have the ROV Water Ready								
Test ROV in the Water and Fix Any Bugs								
Add Ballast								

Appendix B: Check Lists

Safety Protocol

- ☐ Ensure all personnel have no loose hair and are wearing closed toed shoes
- ☐ Before working with the ROV, make sure there are no hazardous objects in the vicinity
- ☐ Ensure all electronics are far from the water
- ☐ Plug in the power from the source to the ROV tether's leads, if silent, proceed
- ☐ Before turning on the ROV, make sure all members are clear
- ☐ All members of the team must have proper communication
- ☐ Check that no wires are exposed
- ☐ Make sure the ROV is lifted so that active pistons will not hit the ground
- ☐ Make sure pneumatic pressure is lower than 40 psi before turning on compressor
- ☐ Before turning on control box, ensure that the box is plugged in correctly

Tether Setup Protocol

- ☐ Make sure the control box will not be tugged when working with the tether
- ☐ Untangle the tether
- ☐ Coil the tether into a figure eight loop (have the ROV end on top)
- ☐ Check to make sure the floats are 1.5 meters apart

Appendix C: System Block Diagram