APTOS
MARINER
ROBOTICS, LLC

Aptos High School· Aptos, CA

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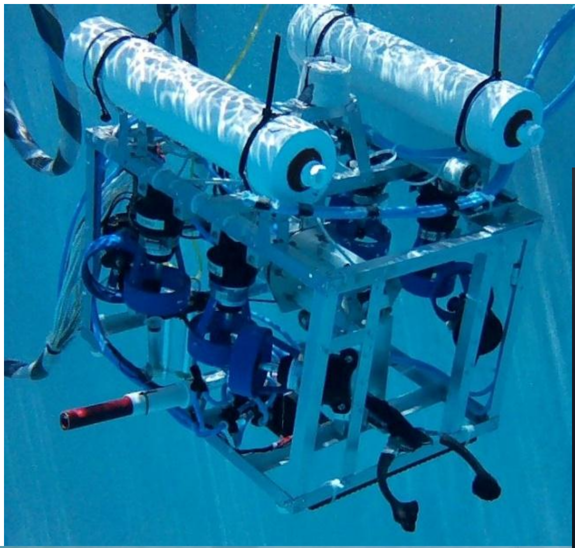

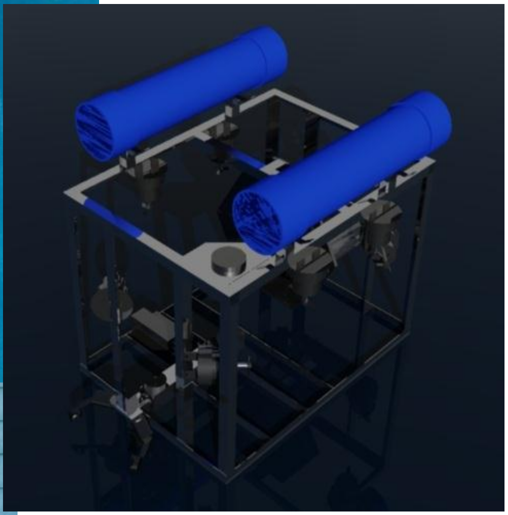

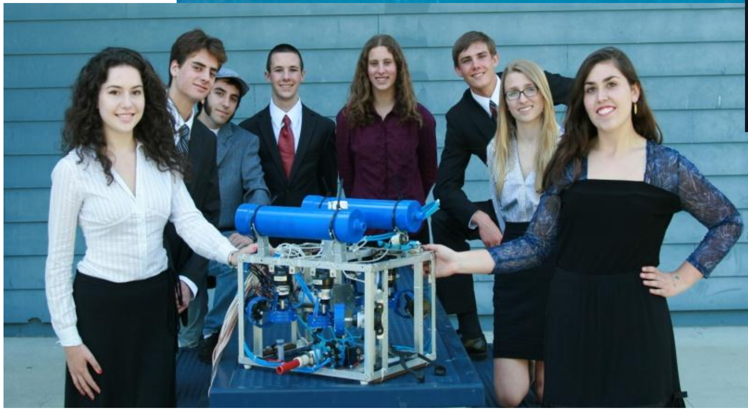

Top Left: The Predator at work
Above: 3D Chassis Drawing
Left: Ms. Hardin, Mr. Sheely,
Mr. Cole, Mr. Randolph,
Ms. Zoliniak, Mr. McMinn,
Ms. Da Costa, Ms. Calcagno

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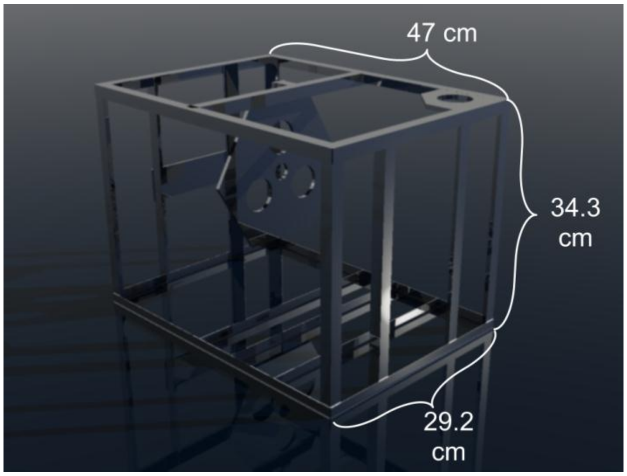


Sketch of ROV Frame

Abstract

Aptos Mariner Robotics, LLC is committed to upholding our tradition of protecting the environment. Our state of the art underwater robot, ***Predator,*** has been designed for reconnaissance missions and environmental preservation. Our ROV specializes in investigating World War II shipwrecks and preventing their presence from degrading environmental conditions. It bristles with sensory equipment, boasting a length measurement device, electronic compass, metal detector, five cameras, a neutron scanner, and an ultrasonic thickness gauge. Furthermore, ***Predator*** is able to save endangered wildlife, sample and seal oil containers, and facilitate the retrieval of objects from the ocean floor. We operate our ROV using a standard Xbox 360 controller, which is connected to the control box via a laptop computer; software then translates the console commands into activation of specific motors. The ***Predator*** has eight 4,731 LPH bilge pump motors, and our innovative Configuration X (see pg. 10) allows our ROV to excel in terms of both speed *and* maneuverability. Combined with our highly effect proprietary payload tools, our robot will clearly demonstrate the capabilities of Aptos Mariner Robotics.

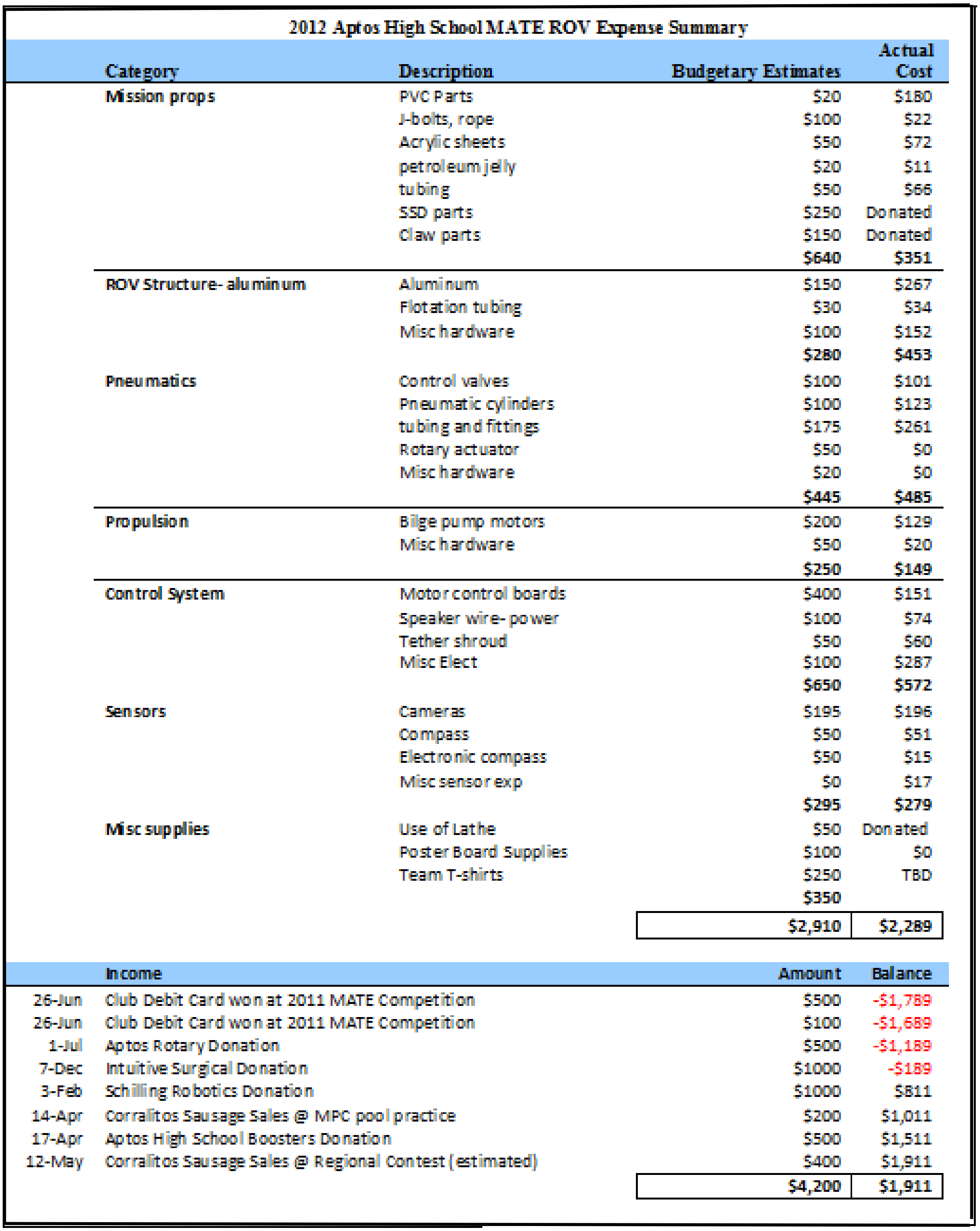
Safety

At Aptos Mariner Robotics, safety is a key priority. We have in place policies that include strict guidelines which we follow at the poolside *and* in the workshop: for example, full instruction is required before new members are permitted to use power tools, safety glasses must always be worn while grinding or buffering metals, and a sterile workplace with ESD protection is required while soldering. At poolside, careful compliance with the Mission Checklist (see Appendix A) ensures safety and efficiency.

We have also included several key safety mechanisms on the ROV itself. These mechanisms include shrouds around the motors (along with caution tags for those unfamiliar with the motors of an ROV), rounded edges, neatly tucked wires, pressure tested pneumatic lines, thermal overload protection, fuses, and slightly positive buoyancy. The shrouds physically bar motors from harming wires, on-board devices, or team members working near the ROV. By filing down edges, we prevent undesirable cuts in wires, devices, and skin. To make sure that the wires do not cause problems, we arranged them so that they are taut and fit neatly within our frame without having any wires sticking out of the ROV. Our pneumatic tubes can handle far greater pressures than are required during the competition. While we operate at 40 psi, the hose boasts a limit of 150 psi. If something were to go wrong on the ROV, we have designed it with slightly positive buoyancy to ensure that it will surface on its own. There are also safety measures which are not located on the ROV. The wires connecting the ROV to our power box and control system are wrapped in a tether sheath. To protect the wiring in our control box, we placed a fuse first in line on the positive line of power. This protects both the equipment and the power supply in case of an electrical fault causing excessive power draw. Our motor controllers incorporate automatic thermal protection to avoid damage under heavy load in hot conditions. Another safety innovation is in our software where ROV status is displayed at all times to ensure we know what the robot is doing. Both a software and hardware kill switch is incorporated into the system to allow immediate shutdown if necessary for any unexpected reason. This is important in allowing Predator to operate safely with divers or other ROVs.

The Balance Sheet

One of our goals this year was to accurately budget for our ROV expenses and keep development costs to a minimum. Our initial projected budget was $2,910, based on our records from previous projects. The actual cost for our prototype development was $2289. In the course of the year, we raised $4,200, leaving a net balance of $1,911 in the ROV account at the completion of the Regional Trials. This will act as seed money for next year and support further fund raising to support team travel. We expect that production costs for the second and subsequent units will be $2,000, enabling us to be cost competitive in the market place.



2012 Aptos High School MATE ROV Expense Summary

Category	Description	Budgetary Estimates	Actual Cost
Mission props	PVC Parts	$20	$180
	J-bolts, rope	$100	$22
	Acrylic sheets	$50	$72
	petroleum jelly	$20	$11
	tubing	$50	$66
	SSD parts	$250	Donated
	Claw parts	$150	Donated
		$640	**$351**
ROV Structure- aluminum	Aluminum	$150	$267
	Flotation tubing	$30	$34
	Misc hardware	$100	$152
		$280	**$453**
Pneumatics	Control valves	$100	$101
	Pneumatic cylinders	$100	$123
	tubing and fittings	$175	$261
	Rotary actuator	$50	$0
	Misc hardware	$20	$0
		$445	**$485**
Propulsion	Bilge pump motors	$200	$129
	Misc hardware	$50	$20
		$250	**$149**
Control System	Motor control boards	$400	$151
	Speaker wire- power	$100	$74
	Tether shroud	$50	$60
	Misc Elect	$100	$287
		$650	**$572**
Sensors	Cameras	$195	$196
	Compass	$50	$51
	Electronic compass	$50	$15
	Misc sensor exp	$0	$17
		$295	**$279**
Misc supplies	Use of Lathe	$50	Donated
	Poster Board Supplies	$100	$0
	Team T-shirts	$250	TBD
		$350	
		$2,910	**$2,289**

	Income	Amount	Balance
26-Jun	Club Debit Card won at 2011 MATE Competition	$500	-$1,789
26-Jun	Club Debit Card won at 2011 MATE Competition	$100	-$1,689
1-Jul	Aptos Rotary Donation	$500	-$1,189
7-Dec	Intuitive Surgical Donation	$1000	-$189
3-Feb	Schilling Robotics Donation	$1000	$811
14-Apr	Corralitos Sausage Sales @ MPC pool practice	$200	$1,011
17-Apr	Aptos High School Boosters Donation	$500	$1,511
12-May	Corralitos Sausage Sales @ Regional Contest (estimated)	$400	$1,911
		$4,200	**$1,911**

Design Rationale: Payload Description

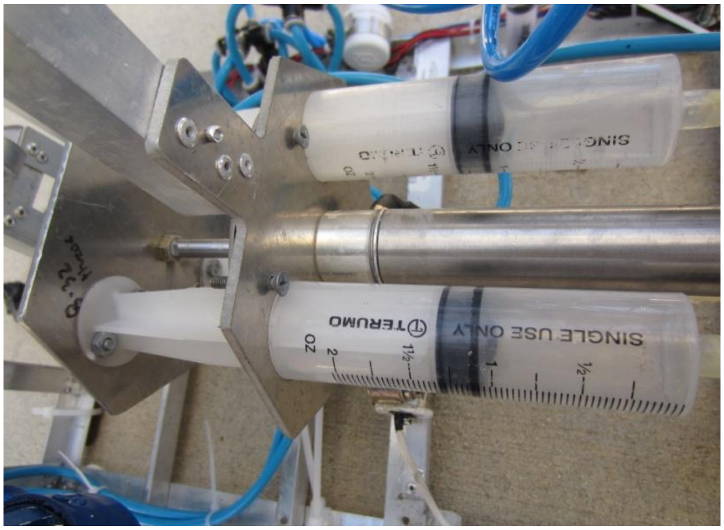
There are two main payload components, the ***Predator***'s claw, and the Super Sucking Device. However, our ROV is also equipped with a length measurement device, magnetic patch deployment device, a collection of sensors to collect scientific data.

Claw

Predator possesses a simple, fixed position claw, which serves various functions, but does not require an extend/retract function, as no objects must be stored for more than a few moments. The claw is built from a trash collector with modified arms to increase reliability of gripping objects. The claw is used to hold the lift bag's hook, transplant coral, and collect the magnetic patch if it were ever to come lose. The claw's default is the closed position so that items are not lost in case of an electrical power interruption.

SSD (Super Sucking Device)

In order to analyze the contents of the bunkers of sunken ships, our ROV is equipped with an SDD, or Super Sucking Device, which is able to penetrate the hull of ship and obtain an undiluted sample of the contents of the hull. The SSD is composed of three 60 mL syringes arranged on the points of an equilateral triangle so that each syringe is equidistant from each other, leading to smoother operation, more efficient application of force, and less resistance. This year, we designed and fabricated parts to hold the syringes in place and to provide a more efficient application of force. The SSD is powered by one pneumatic cylinder connected to a machined aluminum part that holds the cylinders in place while it moves the plungers. The syringes are bolted in using two separate machined aluminum plates, allowing for an easy change of cylinders if necessary. Also, for convenience, we threaded all the holes to accommodate 10-32 screws so we only have to have those screws around. The aluminum part that holds the plungers is threaded at the areas that hold the handles of the plungers, allowing for quick interchangeability. Initially, we used a 1.9 cm diameter pneumatic cylinder, but had to upgrade the size to 2.5 cm due to allow for a greater application of force. The SSD proboscis is mounted on the



A close-up of the SSD syringes

top left front corner of the ROV, connected to a pneumatically-powered servo that rotates the proboscis 90 degrees out in front of the ROV to better collect the fuel from the tank and to keep it out of the way during other mission tasks. A camera is placed along the proboscis so that the Predator's operator can better view the proboscis. The proboscis is attached to the servo using a heavy metal wire fixed to the top of the servo with another aluminum plate. The tubes used for the proboscis are attached to the syringes using a union piece, allowing for an easy switch of any defective tubes. Even if, for whatever reason, one of the syringes or tubes were to fail, the remaining two still have a combined volume greater than the minimum 100 mL ensuring mission requirements can still be met.

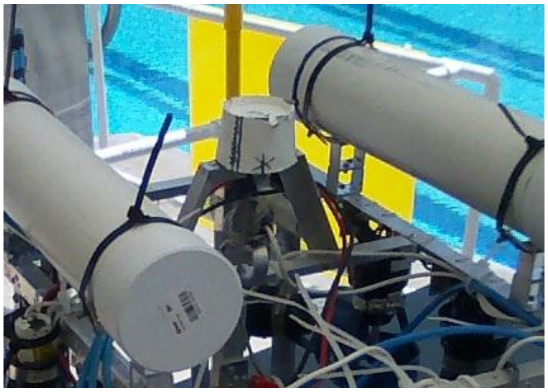
Length Measurement

We mounted two pegs to the robot and ran a thin rope through the pegs' metal rings. ***Predator*** can place one peg into the pylon at the stern end of the shipwreck and drive the other peg all the way to the other pylon, pulling the rope through along with it. After the second pylon is in place, a member of the tether team at the surface can gently pull the slack out of the rope as the robot pivots around to view how much rope has passed through the second pylon. We marked the rope with permanent marker every 5 centimeters along the segment which spans the distance from 2.25 meters to 3.75 meters. We also spray painted every 25 centimeters so we can quickly and easily determine the length based on how many of each tick mark pass the second pylon.

Pegs used for length measurement

Electronic Compass

The compass is used to determine the orientation of the ROV, and thus the shipwreck. Because the readout is electronic, it does not need to be in view of a camera, enabling us to place it high on the ROV, in an area of reduced magnetic disturbance. Our compass is software corrected for residual magnetic interference and mounting geometry.



Predator**'s electronic compass**

Hull Patch Deployment

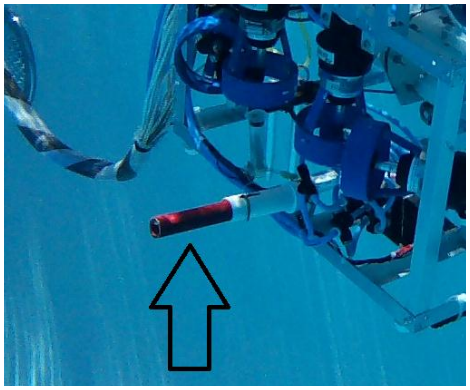
The Magnetic Hull Patch must be stored somewhere reliable for the entirety of the mission, as it is the very last task accomplished, and returning to the surface mid-mission would prove costly. Two sheets of aluminum metal are molded to fit the shape of the cap, which holds the patch until the ROV places the patch against the hull where it self-adheres and the ROV simply drives away.

Metal Detector

Our initial design consisted of a neodymium earth magnet attached to a buoyant cork inside a plastic test tube. Ferrous metal beneath ***Predator*** would cause an attraction of the magnet strong enough to overcome the buoyant force keeping the magnet/cork complex floating. This technique did work, but it proved difficult to find a location on the ROV that could be maneuvered near a test subject while being closely watched by a camera. Eventually, we realized that by using a spring attached to the claw on one end and a magnet on the other would save a camera. Driving the metal detectors to the debris became much simpler for the driver, and it even made proximity less of an issue, as the claw is such an extension outside the frame. When the robot nears the debris, the spring will either stretch or remain coiled, depending on the composition of the debris. Thankfully, an additional camera is not needed, as there is already a camera focused upon the claw.

Ultrasonic Thickness Gauge and Neutron Backscatter Device

Both of these tools are consolidated into a single unit, a PVC tube about 15 cm long. The ultrasonic thickness gauge sends sound waves through a substance and measures the time it takes for the wave to return, and based on this, it determines the thickness of the substance being measured. Based on this, we can calibrate the neutron backscatter device along the appropriate side of the calibration tank. The neutron backscatter device emits high energy neutrons, which degrade into thermal neutrons when they meet hydrogen atoms. Based on the number of rebounding thermal neutrons from the tank, we can determine whether the contents of the tank are oil or water.



The Neutron Backscatter Device/Ultrasonic Thickness Gauge

Design Rationale: ROV Components

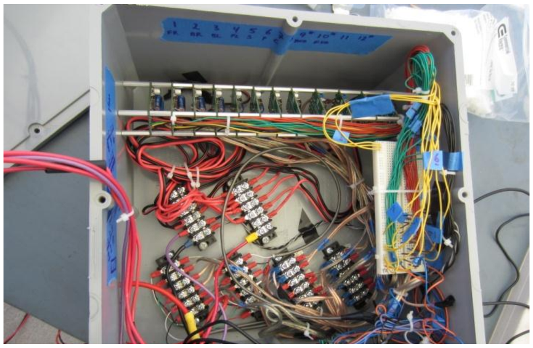
Structure

The Predator's frame was constructed to be as small as possible without endangering the ROV's stability or payload capacity. The frame measures 29.2 cm by 34.3 cm by 47 cm, significantly smaller than our previous models, which combined with our new motor configuration, allows the Predator to turn on a dime and move rapidly from work site to work site.

We used aluminum angle as our primary structural material as it is highly workable while providing superior strength to weight ratio. With our open cage structure, our ROV chassis is easy to adjust for any mission and simple to maintain.

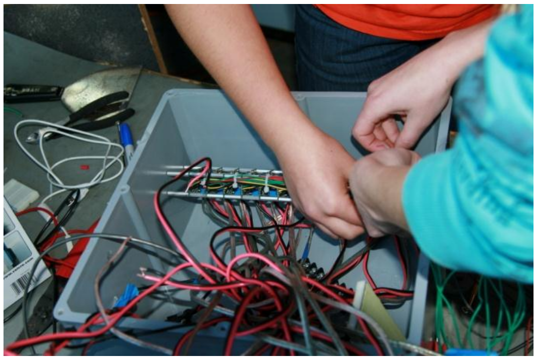
Control Box

Our goal for the ***Predator***'s control box is to make it more reliable and maintainable than our competition's products. This requires more space than our previous models, so we doubled the size of the control box to 30.4 square cm by 15.2 cm tall. This gave us the space to make many positive modifications from the previous Alien model at the same cost, while still maintaining a high level of portability and best in class shore side footprint.



Internal wiring of the control box

This control box features an open layout with plenty of service loop, and includes pre-installed spare motor controllers and USB to serial adaptors. The motor controller stack and terminal boards are tilted to improve access while decreasing the chance of any failures due to excessive wire bending. Our extra motor controller boards can be quickly and easily brought into service due to our use of a bread-board for the serial daisy chain and terminal strips at the tether interface. For the first time, in ***Predator***, we split our motor controllers onto two separate USB to serial adaptors. The two up/down controllers (Pololu simple motor controller 18v15) are connected to their own adaptor, as are the four lateral controllers (Pololu simple motor controller-18v7). Our compass chip also has its own serial adaptor. Separating these has increased the

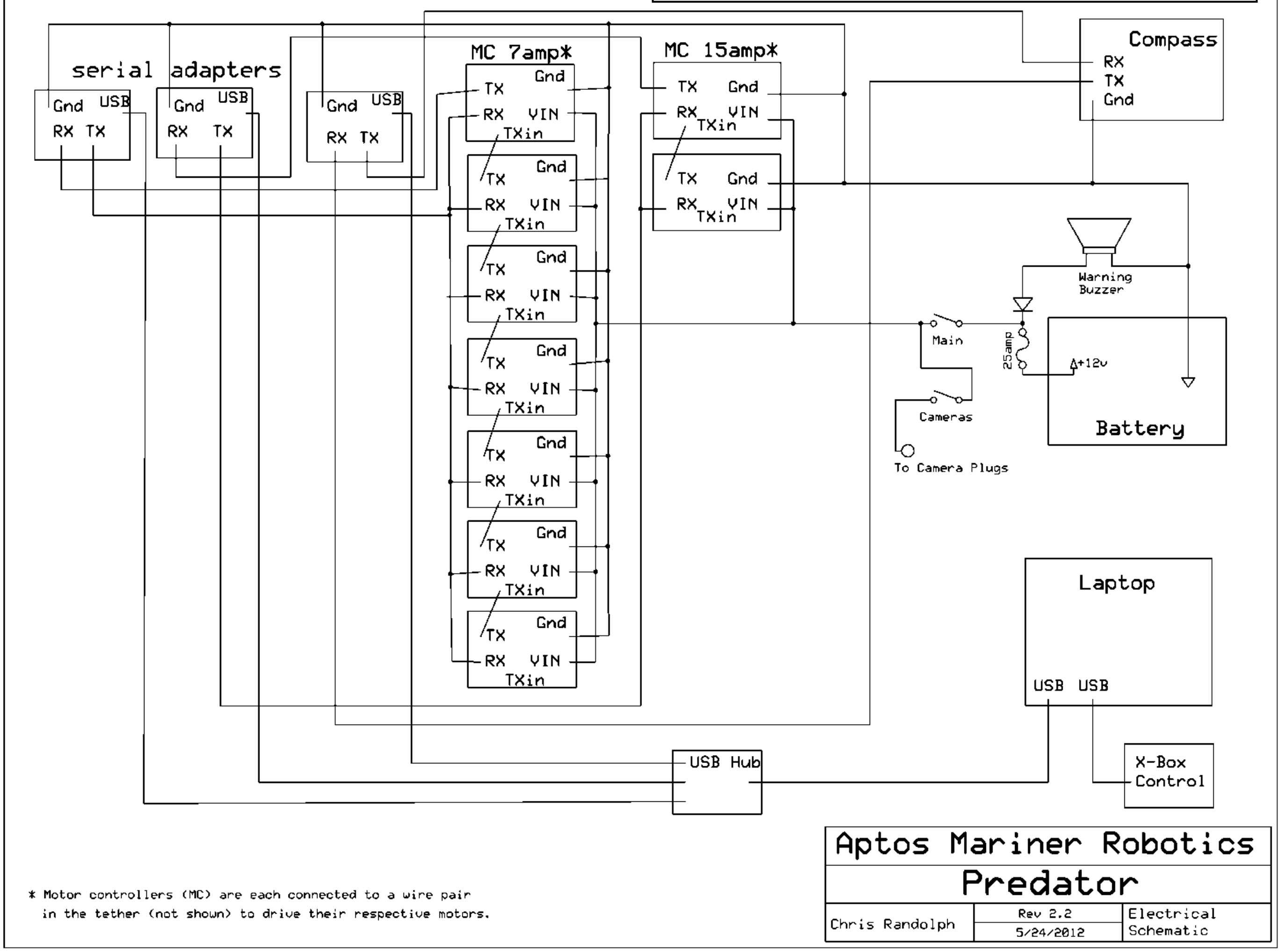


Ms. Da Costa and Ms. Calcagno working on the control box

reliability of our equipment and its capacity to communicate with its companion software.

The first elements in the circuit are the fuse and the power switches for main power and the cameras. Current then runs to the terminal blocks for power distribution. One is for power in and the other serves as the grounding or power out. We use fourteen gauge wire for the main power (from the battery to the motor controllers) and speaker wire (from the motor controllers through the tether). Our use of thick wire for main power prevents extensive voltage drop. From these blocks, power is distributed to the motor controllers then continues to the terminal blocks (through heavy speaker wire) that leads to the tether. From the motor controllers and USB adaptors, smaller, twenty-two gauge wire serves the purpose of signaling between the motors and the computer and has the double advantage of lower cost and taking up less space within the box.

Electrical Schematic

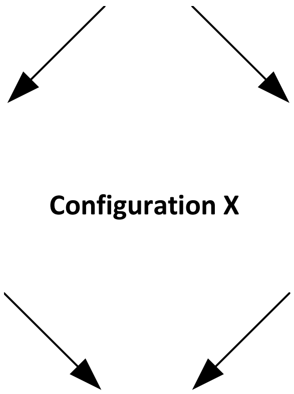


* Motor controllers (MC) are each connected to a wire pair in the tether (not shown) to drive their respective motors.

Propulsion

The ability to quickly maneuver is a crucial time and cost savings advantage in underwater operations. Our ROV is designed for a balance of speed and maneuverability. For our motors we decided to use marine bilge pumps. These are optimum because they are already waterproofed and propellers can be attached relatively easily. We used eight 4,731 LPH bilge pump motors, for the same total thrust as previous models, but with a different configuration for the ***Predator***.

As in previous models, four motors are designated for vertical movement and pitch control, and four are for lateral movement. The innovation this year is the placement of our lateral motors at 45 degree angles and as far away from the center of the ROV as possible. In addition to keeping the center of the chassis free for mission tools, and water flow away from internal obstructions, this configuration also provides more torque for faster rotation, and allows higher available thrust in the fore/aft, and left right directions with all motors firing. The tradeoff with this motor alignment is that the ROV is slightly slower in diagonal movement because only two motors can fire at once, but this is in a direction we rarely use, particular at high speed.


Configuration X

In addition, to improve upon last year's model, we entirely re-made the propeller adaptors, utilizing a lathe to precisely drill holes in an aluminum rod. This allowed for a more precise connection of the propellers to the motors, reducing efficiency and reliability loses to do vibration, as well as reducing weight relative to the previous high part count solution.

Cameras

The Aptos Mariner Robotics team purchased six black and white 7.5 volt security cameras with 17° fields of view (in water). We filled the camera bodies with Epoxy to waterproof the internal wiring, and made sure to avoid contaminating the lens.

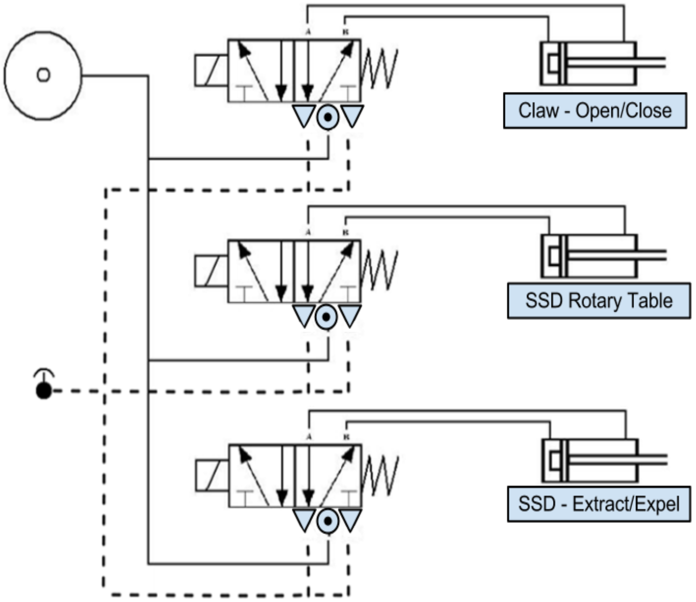
Once ***Predator*** was largely completed, camera placement was worked out. We kept one of the cameras as a backup so we could quickly replace one of the other five in the eventuality of a camera failure. The first and most obvious


One of the five cameras on *Predator*

placement was above the claw, as underwater manipulation of objects would clearly require a viewing range of the claw. The second camera we placed centered near the bow of the ROV, pointing forward and angled downward. This is our main driving camera, and we strove to prevent objects from obstructing its field of view. The third camera we placed above the rotary table which extends the proboscis, as this was required for both the drilling operation and the sampling of fluid. Left with two cameras, we still needed to keep an eye on our length measurement pegs, compass, neutron backscatter device, ultrasonic thickness gauge, magnetic hull patch, and our metal detector. Clearly we had to use cameras for multiple functions or cut down on which tasks required cameras.

After much discussion, we arrived at a solution which allowed us to keep our current cameras where they were with no negative impact on their view range, while using the other two cameras effectively. First, we decided to use an electronic compass, which meant a camera was saved. Second, our metal detector was redesigned (see pg. 7), making it more reliable, and, as it was mounted on the claw, it did not require its own camera. Third, we consolidated the neutron backscatter device and the ultrasonic thickness gauge into a single unit, and thus used a single camera for both tools. We mounted the fifth and final camera at the stern of our ROV pointing down, watching both of our metal pegs for the pilot to drive into the shipwreck's pylons. The final step was mounting the hull patch cradle near the very edge of the field of view of our main driving camera. This allows our driver to carefully seal the sampling hole with the main driving camera, while his field of view remains unobstructed.

***Predator* Pneumatic Schematic**



Pneumatics

The use of pneumatics to power ***Predator***'s SSD, claw, and proboscis extension was an easy decision to make. The compressibility of gases reduces chances of damage to our equipment, as the gas can simply absorb excess force. Pneumatics are more reliable than hydraulics, and provides sufficient force for our needs, while electronic gearboxes would be far slower and require much more waterproofing attention. The use of a manifold allowed us to run all of our compressed air through to the robot through only two tubes, one for supply and one for exhaust, supplying all three of our solenoid values.

The solenoid values are mechanically simple devices which are not water sensitive except for the actuation coils, which are supplied in molded plastic housings which are easily augmented for full water resistance. Long life can be expected from the components provided careful attention is given to post mission wash down protocols.

Software and Motor Control

Efficient mission performance requires the pilot have precise control of the ROV at all times and in all attitudes. 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 payload. 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 manipulator arm and the SSD are controlled via the 'a,b,x,y' buttons on the right side of the controller.

To support our "Configuration X" motor layout, we created a control set which maps user input to each motor based on the motor's direction of influence and how that aligns with the intended direction of motion.

Xbox controller used to operate the ROV

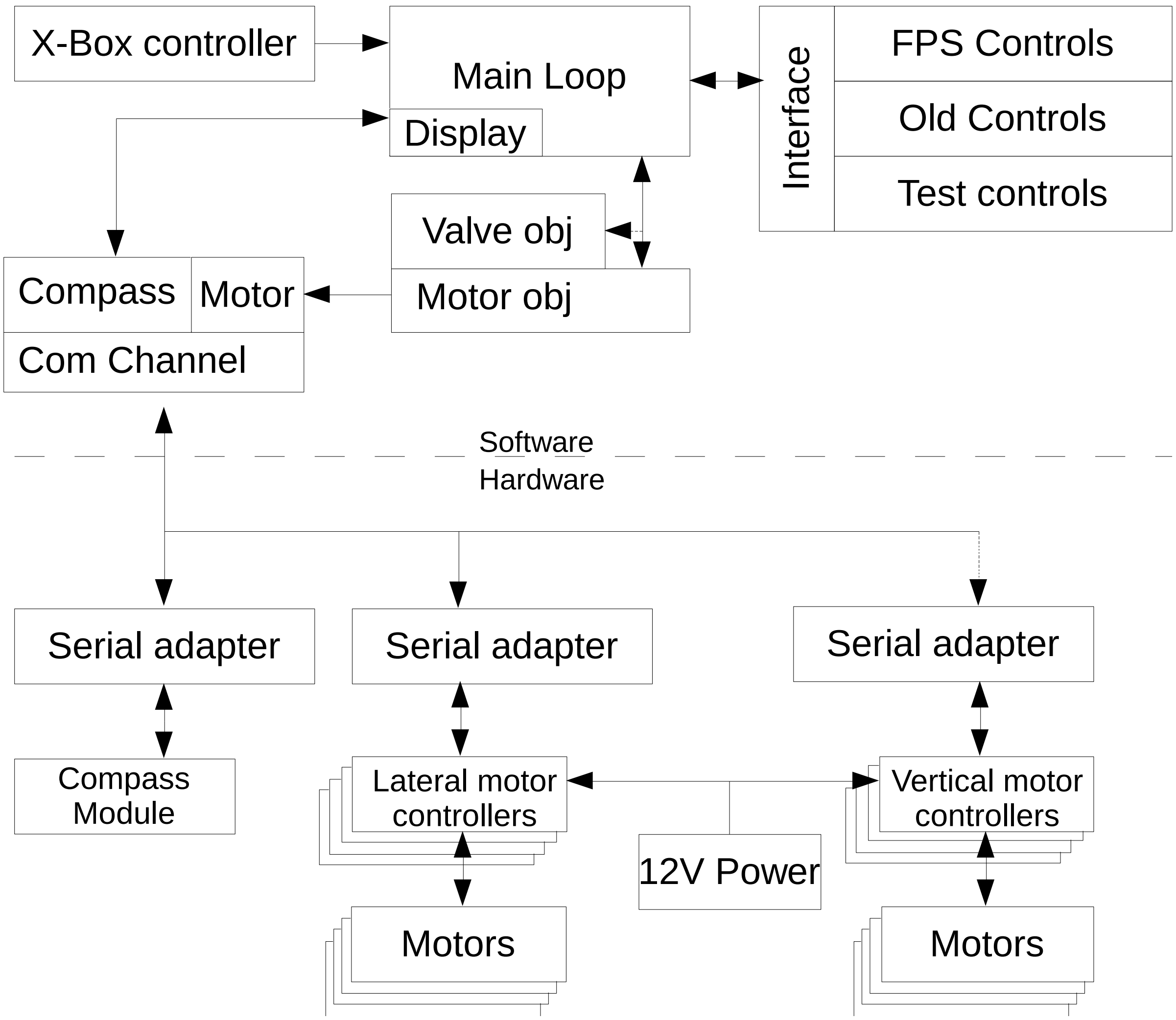
Because several of our tasks require objects in close proximity to the ROV, we created additional control sets to support transparent operation of the ROV with the starboard and stern sides of the ROV treated as the "front" for control law purposes. This allows the pilot to keep control inputs aligned with the chosen camera view while performing side or aft looking tasks. While not essential to any one task, this innovation proved to reduce task time and error rate significantly.

Our software also provides payload and sensor control. We operate our pneumatic system via electrically controlled solenoids whose state is exposed graphically on the software display and controlled via the input devices buttons. We monitor and correct the electronic compass reading we get from the Sure Electronics DC-SS504 Dual-axis magnetic sensor module.

We modified our existing serial communications code so that it could support both the Pololu motor control protocol, as well as the electronic compass protocol. The different types of ports inherit from one original port and then they add the bytes that allow them to communicate with the different pieces of hardware. Responses from the electronics are received immediately from the motor controllers, and asynchronously for the compass.

When the compass was first mounted, we discovered that the motors interfered with the compass. To correct for the deviation we created a table in the software using linear interpolation. We got the coordinates for our table by placing the ***Predator*** on known headings. The X-coordinate represents the reported heading and the Y-coordinate represents the true heading of the robot. The graph was one line that wrapped around the Y-axis. Then we wrote a function which would give us the value representing the difference between true heading and apparent heading. Using this value, we now have the corrected values, that is, the true heading of the ROV.

Predator System Block Diagram



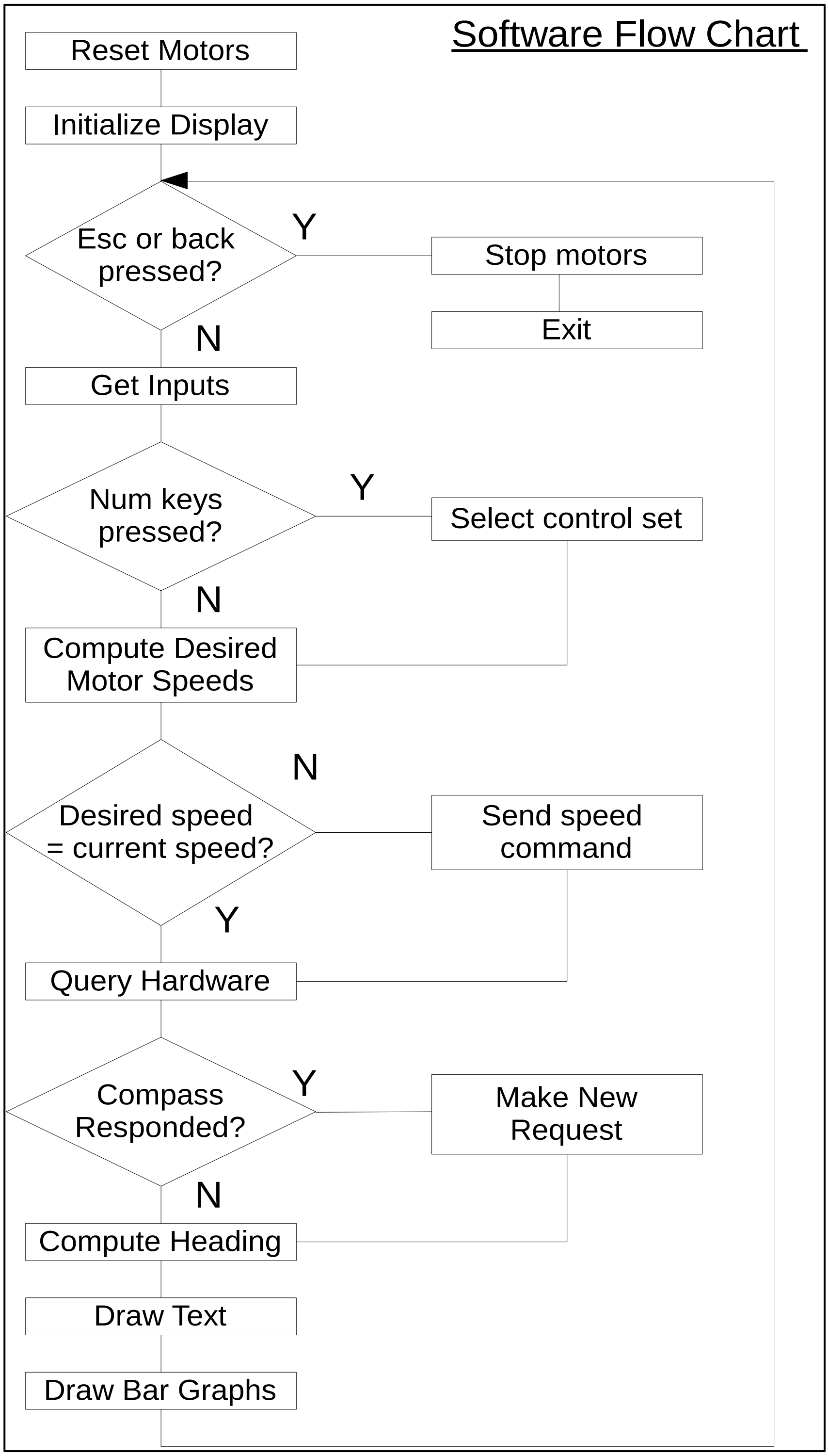
Software Structure

The main structure of the ROV control software is an endless 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. The hardware state is then optionally queried and inspected for errors.

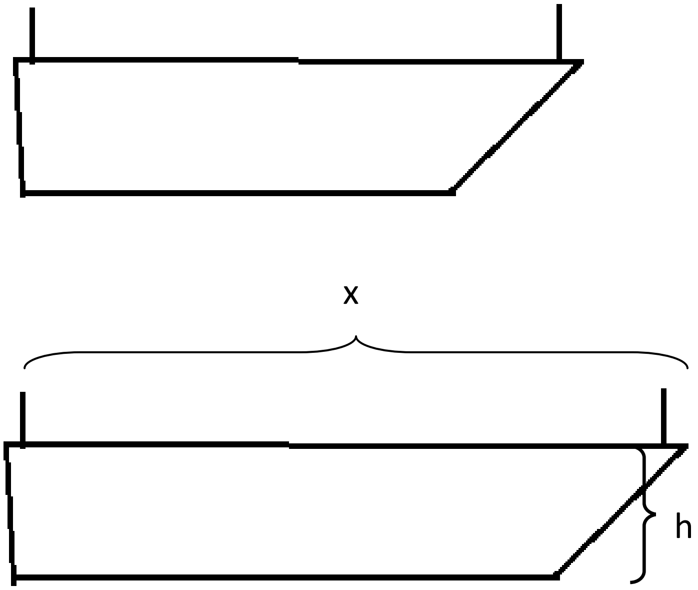
Finally the commands and hardware state are displayed for the operator on the screen in the form of bar graphs and several lines of text. This output aids in situational awareness during normal operations and is essential when troubleshooting problems during development.



Challenges Faced

As an underwater ROV has innumerable moving parts and complexities, there are bound to be challenges associated with assuring the repeatable functionality of the machine. However, such challenges are nothing our qualified team of innovators cannot handle. On the contrary, unexpected obstacles lead to problem solving critical thinking, which oftentimes results in creative solutions and the best design possible.

One issue faced by our design team was finding an effective method to determine the length of a World War II shipwreck. We initially considered taking a snapshot of the ship with the ROV camera to calculate the length. This could be accomplished by using the known height of the ship to determine the length based on the ratio found in the picture.



Initial Measurement Plan

The length:width ratio in the top ship is 4.11 while the bottom ship has a ratio of 4.57 Assuming the height of the shipwreck is kept constant, depending on the ratio found with an ROV, we could calculate the corresponding relationship.
If x=displayed length h=displayed height X=actual length and H=actual height
$X/H = x/h$
$X/H =$ displayed ratio
$X = H*$displayed ratio
Thus, multiplying the true height of the ship by the displayed ratio on the TV monitor gives the true length of the shipwreck.

Unfortunately, in order to get such a picture, the ROV would have to be at a right angle to the shipwreck and significantly far from said shipwreck, due to narrow field of view of our cameras. After testing, the margin of error due to camera imperfection and differential angle viewing led our team to consider more precise and reliable methods of measure. A more viable option, the use of a marked rope strung through two metal pegs was soon adopted, a simple and reliable method. A weakness in our initial idea only strengthened the resultant length measurement technique as we specifically designed it to avoid the problems encountered in the initial plan.

Another challenge faced by our team was the loss of our CEO two months before our regional competition. Since our CEO was in charge of scheduling meetings, and his house was the location for our build meetings, his departure from the team led to a logistical challenge. To resolve this, our Vice President, Mr. Chris Randolph, stepped up and began coordinating meetings in addition to his role as lead programmer. As Mr. Willy was our planned pilot, we also had to train a new pilot as no one else had any significant operation experience.

Troubleshooting and Testing

To ensure that the Predator functions at its fullest potential, we anticipated potential problems and sought out solutions before they could occur. We utilized an FMEA risk analysis (see Appendix B). For example, analysis of the SSD suggested that the use of CAD to design our metal parts would be an effective way to prevent misalignment with the sucker. We tested a prototype to find the mean time between failure (MTBF) of our motors and payload tools. To circumvent issues with our power box and visual system, created a control box with modifications to ensure reliability and we fully waterproofed all cameras. We carefully waterproofed them by drilling a hole in the back of each one and then filling the camera body with epoxy. We tested each camera by submerging it underwater and verifying reliability. In addition, the control box was constructed to avoid any potential threats to its success by sealing against accidental water intrusion. Inside of the box are spare motor controllers that make it easy to replace broken controllers or add more tools with minimum work. However, with as with any machine, unforeseen issues do arise, so it is important to have a testing program and a systematic response to problems.

Out testing program consisted of initial speed and maneuverability trials of our prototype Configuration X motor layout versus a more traditional motor layout. We then tested payload tools as they came on line, first on land, then in the water. Once we have our production ROV assembled, we began a series of progressively more complete mission rehearsals.

When problems did arise, we found that this simple checklist could diagnose most issues:

1) Check power supply to all essential components
2) Verify tether is not impeding ROV movements and is properly buoyant
3) Check computer display to make sure the correct motors are being activated
4) Evaluate ROV buoyancy for neutral to slightly positive
5) Surface ROV and investigate to see if motors or propellers are broken or inactive
6) Investigate software irregularities and explore ROV operation with “Test Controls” mode
7) Open control box to search for detached wires and monitor LED status indications

For example, in one instance the ROV proved difficult to control in the pool. After checking the power, tether and other items, we realized, through use of the isolated test controls, that the robot’s movements were not correct because several of the motors were being activated in the wrong combinations. The software was quickly corrected and testing resumed.

Investigating World War II Shipwrecks

World War II Shipwreck

World War II required billions of gallons of oil to provide the concentrated energy needed to power battleships and land vehicles. This oil was often delivered to the various overseas combatants in tankers. Of course, these oil bearing ships became important targets for submarines and, consequently, many oil tankers now lie at the bottom of the sea. Indeed, the Germans alone sunk forty-two American oil tankers, each one holding thousands upon thousands of gallons of oil. Over 6,000 oil filled ships still litter the ocean's floor and present potential threats to local environments.

As an ROV company is called in, they must be mindful of both the shipwreck and the surrounding environment while operating in such areas. The families of those who died on any sunken ship would likely be averse to excessive meddling in the resting place of their relatives. Therefore, we conduct our operations with minimal disturbances to the actual shipwreck and much of our activity is concerned with non-invasive reconnaissance.

Obviously, environmental concerns remain the highest priority. Preserving biodiversity in a rich habitat such as a coral reef is of utmost importance to our company. We have designed our claw in such a way that biological samples collected and relocated remain undamaged. Furthermore, our magnetic hull patch, used to seal the sampling hole, allows our company to stem the efflux of biohazardous oil into the environment.

Containment of an oil spill

Sources:

http://www.show.me.uk/site/news/STO1135.html

http://www.abovetopsecret.com/forum/thread567113/pg1

http://www.i-dive.com.cy/WreckDiveSites/LibertyWreckProtaras.aspx

http://www.uboat.net/allies/warships/ship/5509.html

Reflections

Personal and professional accomplishments

Being a part of the robotics team has opened new doors for me, both professionally and personally. I had never thought of working in the marine field or in engineering, but now that I have had an introduction to them, they are both possibilities. I also discovered that I enjoy collaborating with a team to form ideas and then make them a reality. Going to businesses and telling them what we have done trying to raise money for our club has been a wonderful experience. I enjoyed pitching our company and raising money to continue and expand our robotics club.

Kayla Zoliniak - Junior (First Year MATE Competitor)

When I first became part of the ranger robotics team last year I enjoyed the benefit of an experienced team. This year we had to make the team from scratch with only two returning members. This was a unique experience that has taught me how to recruit others to challenging projects and how to organize a team of people. I am grateful that I have been able to be a part of this amazing competition.

Chris Randolph - Sophomore (Second Year MATE competitor)

I learned the basics of circuits from my AP physics class, but making the ***Predator****'s control box has taught me more than I ever thought I could learn about wiring. Now I am confident with all the components necessary in a control box and feel like I can easily construct another system next year. In addition, as the lead electrical engineer, I became more confident about making decisions and became a better leader when I organized meetings for our small electronics crew. I will use the skills I have gained from this year next year on the ranger team, and probably for the rest of my life.*

Serena Calcagno - Junior (First Year competitor)

Especially this year, ROV has taught me a great deal about technology and functioning in a group. Through extensive work with the control box, I gained experience in electrical engineering which involved soldering, working with motor boards and wiring. Through the ROV club, I also received a job teaching younger students about ROVs, which gave me practice in leadership and collaboration. It is a great feeling passing on knowledge about something as rewarding as ROVs. Being on the ROV team has increased my passion for machinery and has given me invaluable skills that I can use in the future.

Bailey Da Costa- Junior (Third Year MATE competitor)

Future Improvements

Aptos Mariner Robotics is committed to delivering timely products while constantly raising our own standards. From our experience with this year's ROV, we have identified areas for improvement for next year's model.

One of the toughest aspects of the pilot's occupation is the need to keep the ROV steady while performing tasks which require precision. Though the pilot can counteract any force using the motors, our team recognizes the benefits implicit if the driver did not have to constantly stabilize the ROV. It may be worthwhile to develop a software program which self-corrects the ROV, stabilizing it. This could be accomplished by creating a depth sensor, which activates the appropriate motors if the depth begins to change. The software would ensure that the magnitude of the response is directly proportional to how quickly the depth is changing, to ensure just the right counterforce is provided to keep the ROV steady. Another method which could be explored to reduce pilot workload would provide a "trim" control for the pilot without the need for a precision depth sensor. Once the driver has established a hover through conventional methods, they may simply activate a software mode which "locks" the motors at their current power output. Those motors would remain as they were, but the pilot would not have to hold the buttons, and would be free to drive with his normal controls applied over the top of the "locked" inputs.

Another idea which we plan to implement next year is to improve the quality of our cameras. We will purchase color cameras, which will allow us to better differentiate between underwater features and should even help colored objects stand out. Even more importantly, we plan to equip our robot with cameras which have a wide field of view. Our current cameras have a field of view of only 17° which is an issue in several mission tasks. A camera with a wide field of view would make surveying the grid far easier and quicker, and would allow us to scan the shipwreck without moving so far away. Valuable minutes could be saved by purchasing wide angle cameras, at least for the main driving camera.

Lessons Learned

Aptos Mariner Robotics has had ample opportunity for learning this year. Our team is composed entirely of members new to Ranger level, except for our CEO, Mr. Chris Randolph, who had never driven an ROV before this year. As such, our robotics team has learned all about the myriad components to an ROV and the various concepts such as fine-tuned buoyancy, motive force, motor torque, pressure, and electricity and real life applications of these. To connect our software to ***Predator***, our electronic engineers built our control box from scratch and learned about voltage drop, strain relief, service loops, and ESD, as well as reading data sheets and wiring to ensure hardware compatibility with our software.

Furthermore, our team has learned how to cooperate with each other and collaborate together to determine the best way to proceed in the different tasks. We have also begun comprehend the importance of the scientific method, as our various experiments with our robot give us a clear place to continue our innovation.

Aptos Mariner Robotics also learned how to approach businesses successfully during our fundraising efforts. Our team has become more professional for our engineering evaluations. We have also gained valuable practice keeping calm during intense situations, allowing us to respond with composure if a tether were to become tangled, for example.

Finally, we were able to adhere to deadlines, as we set specific goals for ourselves. At times our project wondered with little progress until a deadline approached and the team came together to meet the challenge. We decided in the beginning that we would have at least 3 cameras fully waterproofed before the Mission Specs were released. When we planned that we would finish the mission props within one month of the release of the mission specs, we beat that deadline and got a head start on mission planning. We aimed to have the ROV complete in March, and although that proved more time consuming than anticipated, our team pulled together to catch up in early April in time to allow pool practice before Regionals, indicating that a more detailed schedule up front might have helped.

Acknowledgements

We would like thank:

- Marine Advanced Technology Education Center (MATE)
- Our team sponsors:
    - The Aptos Rotary Club
    - Schilling Robotics
    - Intuitive Surgical
    - The Aptos Booster Club
- Mr. Casey O'Brien, our Principal, for the use of the school pool and facilities
- Mr. Joe Manildi, our staff advisor
- The Aptos Booster Club, for their financial support of our ROV
- Mr. Willy and Mr. Randolph for their guidance and support throughout this project
- Mr. Jim Triplett, the AHS Swim Team Coach, for sharing the pool with our ROV
  All those supporting our fund raising raffle for travel expenses
- All of our parents and families for their patience, encouragement and support for our Team and our ROV project. Thank you!!!

Appendix A: Mission Checklist

Pre-mission setup

Desk

O Switches off

O Battery connected – Verify no buzzer

O TVs plugged in and on

O Cameras connected to correct ports

O Get “all clear” from poolside

O Switches on

O Make sure ROV devices are functional

Poolside

O Lay out air hose, tether, and measuring line

O Attach tube to lift bag

O Power up compressor — verify 40 psi

O Get “all clear” from pilot

O Connect pneumatics - exhaust away from desk

O Set pins in place — slider on right

O Grip lift bag with claw — hook facing right

Task 1 Survey Shipwreck Site (Any Order)

O Length of ship

O Orientation of the ship

O Debris field map

O Debris field metal/nonmetal

O Sonar 1

O Sonar 2

Task 2 Remove Fuel Oil from the Shipwreck (In Order)

O Lift Bag

O Coral

O Ultrasonic Thickness Gauge

O Neutron Backscatter Device

O Fuel Sample

O Magnetic Patch

O Deliver Sample

Post-mission clean up

O Disconnect compressor air and power

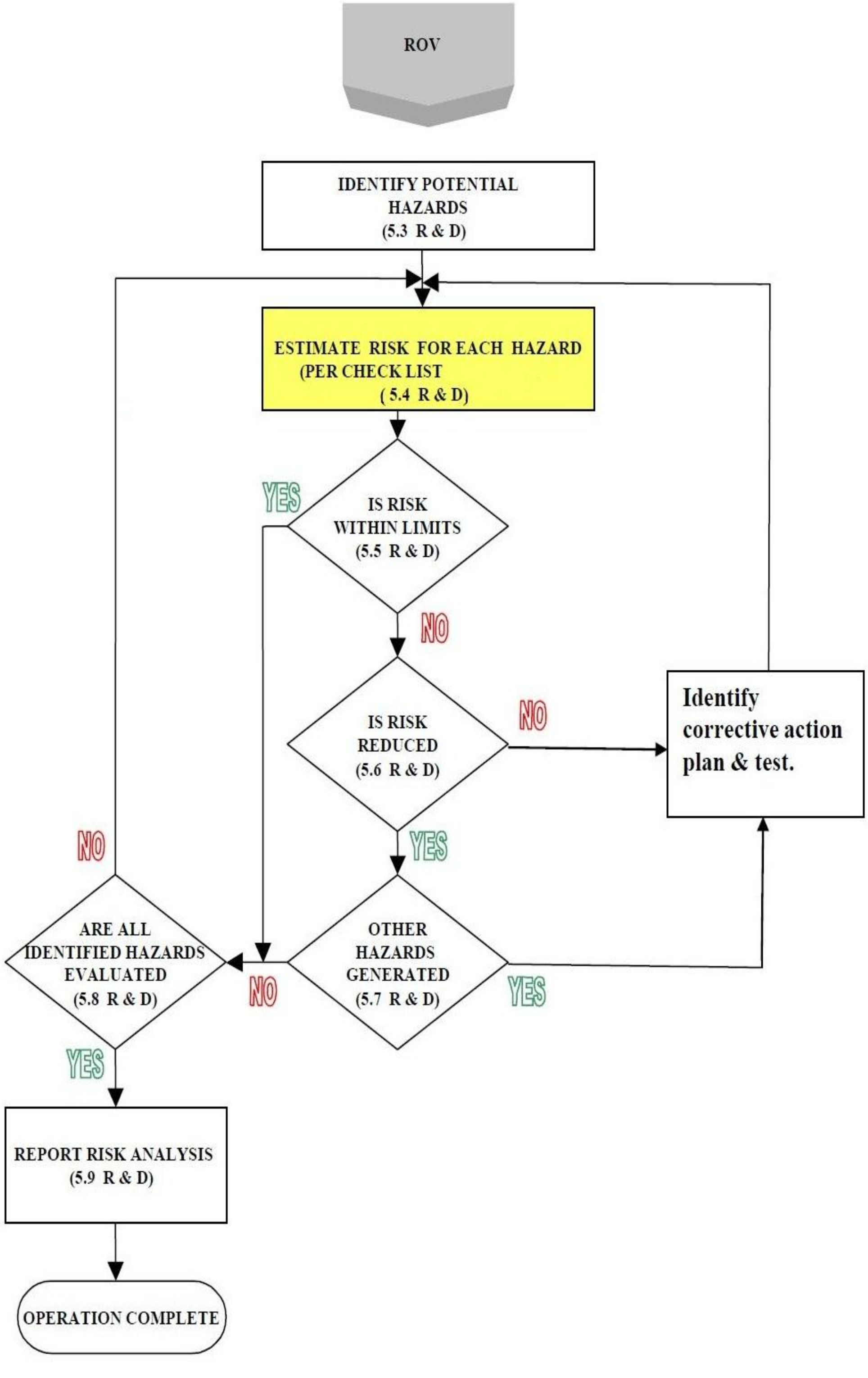
O Turn off control box

O Unplug battery

O Read scoring sheet

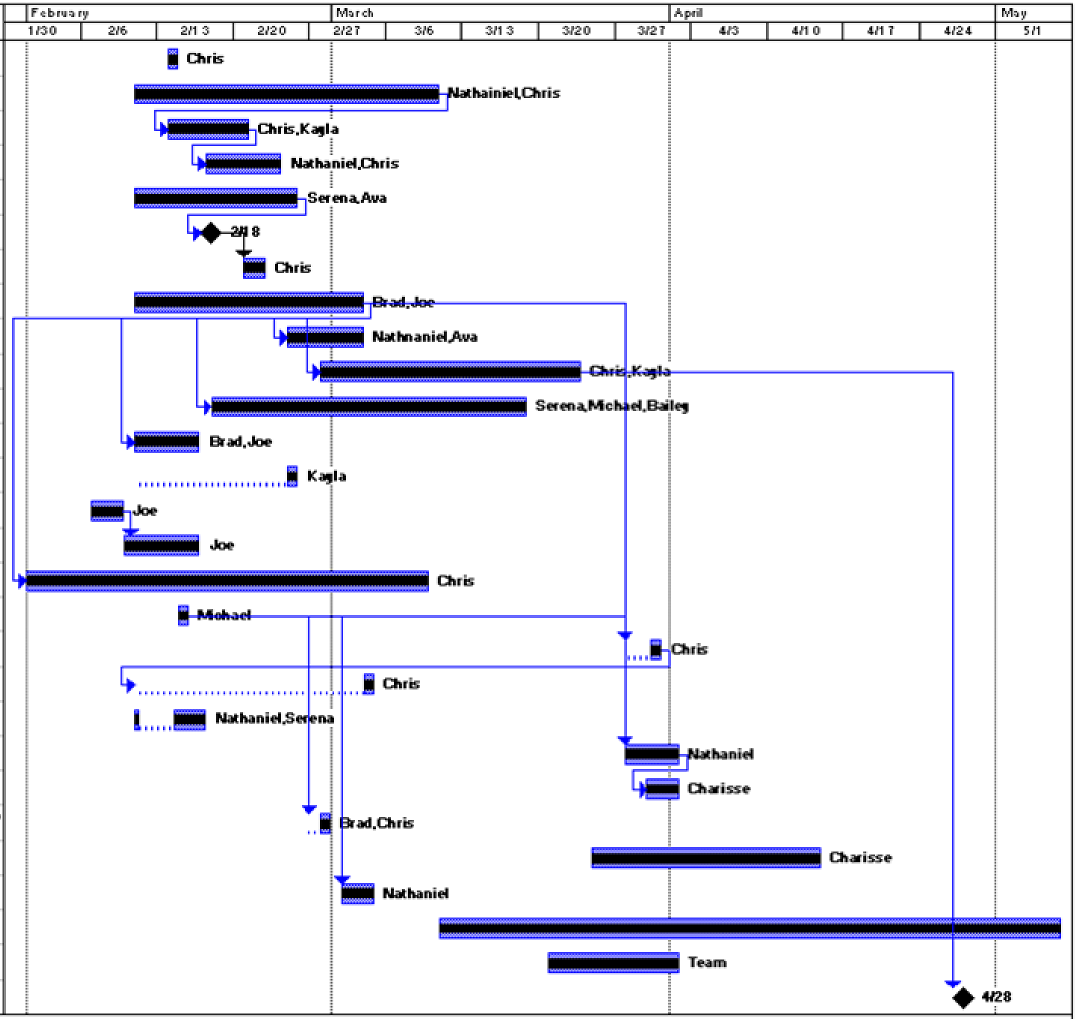
O Sign scoring sheet

Appendix B: FMEA Flow Diagram



Appendix C: Aptos Mariner Robotics Schedule

ID	Resource Names	Task Name
1	Chris	Register Team MATE
2	Nathainiel,Chris	Design Build X Config Prototype
3	Chris,Kayla	X Config Software
4	Nathaniel,Chris	X Config Propulsion
5	Serena,Ava	X Config Control Box/Electrical
6	Team	X Config Test Run
7	Chris	Mill & Mfg Motor Couplings
8	Brad,Joe	Build Predator Production Frame
9	Nathnaniel,Ava	Waterproof Cameras & install
10	Chris,Kayla	Predator Software
11	Serena,Michael,Bail	Predator Electrical System
12	Brad,Joe	Predator Propulsion System
13	Kayla	Predator Compass
14	Joe	Super Sucker SSD
15	Joe	SSD Cad & Machine Mill
16	Chris	Purchasing / Planning
17	Michael	Measuring Device
18	Chris	Neutron Back Scatter
19	Chris	Ultra Sonic Thickness Gauge
20	Nathaniel,Serena	Wire Motor Controllers
21	Nathaniel	Wire Pneumatic Solenoids
22	Charisse	Build Tether & Tubing
23	Brad,Chris	Floatation Chamber & Center of Bouyancy
24	Charisse	Poster
25	Nathaniel	Install Cameras
26	Michael	Tech Report
27	Team	Engineering Review Prep
28	Team	Trial Run & Test



Project: 2011 Ranger Schedule
Date: Wed 5/23/12

Task	▨	Milestone	◆	Rolled Up Split	┈	External Tasks	▨
Split	┈	Summary	▬	Rolled Up Milestone	◇	Project Summary	▬
Progress	▬	Rolled Up Task	▨	Rolled Up Progress	▬		

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