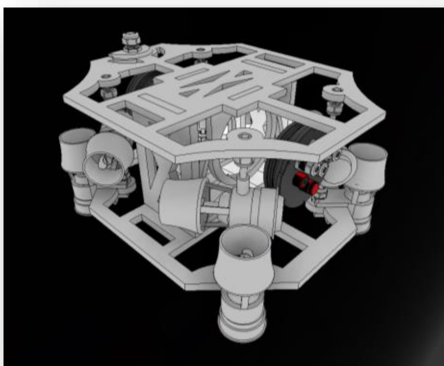
SEA SWEEPERS

HIGHWAY 68 ROV CLUB

SALINAS, CA

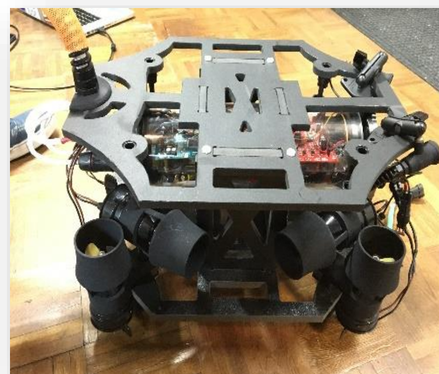
HTTP://SEASWEEPERSROV.COM

5/26/2016 | Technical Report



CAD ASSEMBLY

BRUCE 2.0



FINISHED VEHICLE

TEAM MEMBERS

JP O'Dell - 7th year – Chief Executive Officer; Pilot

John Yeager - 7th year – Chief Operating Officer; Mission Strategist

Michael Georgariou III - 2nd year – Motor Control Programmer; Co-Pilot

Tyler Allen - 2nd year - Head Engineer; Poolside Assistance

Chase Oleson – 1st year – 3D Modeler & Electronics; Poolside Assistance

Hanna Hitchcock - 1st year – Chief Financial Officer & Documenter; Tether Manager

Brian Ishii – 1st year – Sensor System Programmer

Montana Sprague – 1st year – Project Manager & Technician

Jack Hyland – 1st year- Assistant Vehicle Designer & Engineer

Mentored by: Kurt Yeager & Mike Allen

* Team Position
* Mission Position

Sea Sweepers Tech Report

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ABSTRACT

For seven years, the Highway 68 ROV Club, also known as the Sea Sweepers, has been building vehicles and enjoying tremendous success in the pool. Established in 2010 with four fifth grade boys, we have grown significantly over the past several years to our current membership of nine active team members. We have achieved first place overall in the Scout, Navigator, and Ranger classes at the Monterey Bay Regional MATE competition; two years ago, we swept the competition in the Navigator class and subsequently moved up to the Ranger level. Over the years, we have learned a variety of important life skills: experience with electronics, background in business and administration, and especially the value of teamwork.

This year, the upcoming competition theme is based on a space missions to Europa. From the very beginning, our team has been building vehicles as simply as possible; instead of focusing on complex hydraulics, metal frames, and 3D-viewing goggles, we concentrated on the essentials. However, at the beginning of this building season, we decided to completely redesign and upgrade our vehicle, creating a CNC cut high density polyethylene frame, 3D-printed motor mounts, and a full digital control system.

We won the Monterey Bay regional competition last year and placed 13th out of thirty-four teams at the international competition in Newfoundland, Canada. This year, we hope to defend our local title and participate in the international competition in Houston.

BIOGRAPHY

Founded in 2010, the Highway 68 ROV Club consisted of four inexperienced, but ambitious fifth-grade boys. Seven years later, the Sea Sweepers are still alive and well, maintaining an expanded team of nine members with two from the original team. A unique aspect of the Sea Sweepers is that we are an independent club, which allows us to invite members from multiple schools. Building vehicles and pooling sponsorships have brought us together as a club and taught us the importance of teamwork; everything we achieve is an accomplishment for the benefit of the group. By challenging ourselves to meet self-assigned deadlines and finish our work efficiently, we have learned how to juggle different commitments, complete our tasks, and have fun while working. Our work ethic translates into our continued success at the competition, and these experiences will help us become the hardworking and dedicated engineers and programmers of the future.

This year, we have recruited new team members with the skills that we need to meet the new task requirements. This allows us to expand our capabilities and build an elaborate vehicle using the different perspectives and knowledge of the new members combined with the experiences of the old members.

THE 2016 SEA SWEEPERS: (FROM LEFT TO RIGHT) MENTOR KURT YEAGER, CHASE OLESON, JOHN YEAGER, MONTANA SPRAGUE, MICHAEL GEORGARIOU, JP O'DELL, JACK HYLAND, HANNA HITCHCOCK, TYLER ALLEN, BRIAN ISHII, MENTOR MIKE ALLEN

TEAM SAFETY PHILOSOPHY

As an engineering and designing team, the Highway 68 ROV Club regards the safety of its members as its first priority. In order to stay safe at all times, we enforce very strict rules in both the building process and around the pool. By taking these necessary precautions, we protect ourselves from any conceivable danger associated with underwater robotics and marine technology.

BRIAN AND JOHN PRACTICE SAFE CONDUCT WITH PROTECTIVE GOGGLES.

Maintaining an organized, orderly workspace is essential to ensuring our safety and protecting us from accidents. Tripping hazards and electrical mishaps are avoided by storing wires, parts, and any tools in specifically marked locations. Safety glasses and other protective articles are mandatory whenever we are cutting, soldering, or using any potentially dangerous tool. To ensure the safety of both the team and the vehicle, we are careful to keep the electrical components away from the pool. All of the electrical components on the ROV are carefully waterproofed.

In addition to building the vehicle safely, we also make sure to build a safe vehicle. All of our motors are shrouded, preventing damage from the sharp blades of the propellers. Potentially dangerous rough or sharp parts are filed or removed. All exterior parts of the vehicle are safe to touch, thanks to our meticulous safety protocols.

SAFETY CHECKLIST

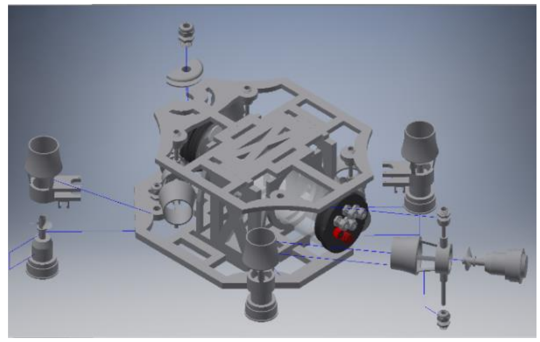
- ☐ All connectors securely connected
- ☐ All wiring fastened securely
- ☐ 25 amp fuse in place
- ☐ Tether secure on both the ROV and box end
- ☐ No exposed propellers
- ☐ All wiring in control box is enclosed
- ☐ Poolside assistance wearing safety goggles and closed toe shoes
- ☐ Circuit breaker on
- ☐ Main power on
- ☐ Check that voltage is as expected (12-14 V)
- ☐ Check that idle amperage is as expected (1-2 A)
- ☐ Continue to pre-mission checklist

OVERALL DESIGN

Our vehicle is made up of a High Density Polyethylene frame. It holds 8 brushed thrusters: 4 horizontals and 4 verticals. The thrusters are housed in custom 3D printed mounts with integrated propeller guards. An onboard waterproof tube houses the electronics that drive vehicle and send data back to the control box. An onboard Arduino Mega receives Serial RS-232 signals and decrypts them to control the motors. A second onboard Arduino gathers sensor data such as depth, temperature, voltage, and current. On the surface, the ROV is controlled with an integrated control box. Analog joysticks send signals to a surface Arduino which converts the signal to RS-232 and sends it to the vehicle. The cameras are displayed through a video multiplexer, which allows us to see 4 cameras at one time. A second screen displays all of our telemetry data.

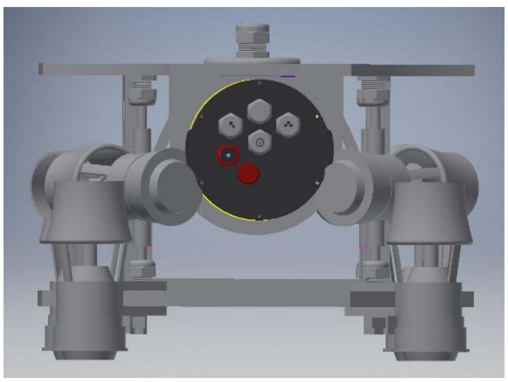
3D DRAFTING AND DESIGNING

Our team used Autodesk Inventor Professional throughout our design and drafting process. In terms of drafting, we maximized the top and bottom plate's size within the parameters of a 48 cm diameter circle by drawing within the target circle itself. We chose to hand tap our threads instead of incorporating them in our 3D printed files for the sake of ensuring a watertight seal. By using the Stress Test feature in Autodesk, we were able to ensure alterations were not jeopardizing the integrity of the parts.



CAD DRAWING: EXPLODED VIEW

Our vehicle maintains a minimalist, but dimensionally and hydrodynamically efficient design. For example, for the sake of both structural integrity, as well as the luxury of having adjustable vectored horizontal motors, we designed the horizontal motor mounts to span the height between the top and bottom plates and rotate between two adjustable cord grips. These four mounts and the holes cut in the plates to hold them were precisely placed to avoid hitting our other motors, the electronics tube, and the frame itself.



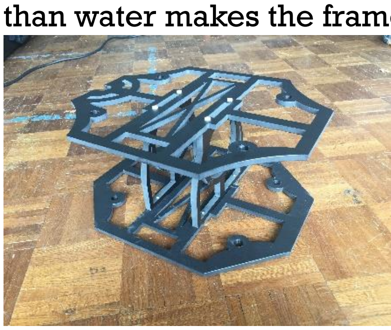
CAD DRAWING: ENDCAP VIEW

VEHICLE COMPONENTS

FRAME

Our team made designing the frame one of our top priorities. Deciding between acrylic and high density polyethylene (HDPE), we chose HDPE as our frame material because it is stronger, cheaper, and less dense than water. Having a material lighter than water makes the frame lighter and reduces the requirement of buoyancy foam to keep afloat. The only foam needed on the vehicle supports the weight of the motors and payload tools. We made our vehicle lighter and more hydrodynamic by cutting strategic holes in our top and bottom frame plates as well as in the side support plates.

UNASSEMBLED HDPE FRAME



ASSEMBLED HDPE FRAME

We kept a few key goals in mind as we designed the frame. First, we were able to keep our vehicle compact by ensuring the main frame remained within the 48 centimeter circle. We also decided to make our attachments and motors removable. Using the 3D computer modeling program Inventor Pro (page 4), we designed the vehicle small and easily manageable.

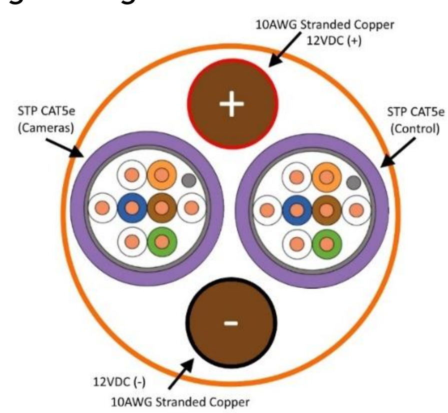
WATERPROOF ELECTRONIC HOUSING

In order to minimize the wires in the tether, we have implemented most of our electronics inside a waterproof acrylic tube on the vehicle. This waterproof enclosure houses two Arduino Megas, 2 four channel motor control boards, RS-232 converters, and assorted sensors that are mounted on a shelf inside the tube. We designed the shelf to maximize useful space by mounting components to the top and bottom. We implement over 15 O-rings on the tube keeping the various connectors waterproof. Wires are brought in and out of the tube using waterproof cord grips. In order to ensure the tube is waterproof, we use a vacuum pump before every pool test to extract all the air in the tube. If there are truly no leaks, the tube will maintain its zero air pressure.

WATERPROOF ELECTRONIC HOUSING

TETHER

The primary consideration for the design of our tether was weight. A lighter tether limits drag on the vehicle. A lighter tether is also easier to manage and cheaper to transport, effectively optimizing the vehicle to be launched into orbit for a mission to Europa. The tether contains two 10-gauge wires to power the vehicle and two STP CAT-5E cables for communication with the controller boards mounted on the vehicle. This four cable design keeps the tether light and flexible, and allows for a more agile vehicle. We chose an aircraft avionics connector to detach the tether from the control box. This connector is durable and allows for a reliable and safe connection. On the vehicle end of the tether, we chose three separate, lightweight plastic connectors. These connect into the back of the waterproof electronics housing on the vehicle.



TETHER CROSS SECTION

BUOYANCY AND BALLAST

We designed our vehicle to be as stable as possible within the weight requirements. The primary stability principle we use is polarity. A polar vehicle is denser towards the bottom in order to create ideal stability. The design of our vehicle itself is naturally polar, meaning we don't have to add unnecessary weight to stabilize our vehicle. The higher density thrusters are mounted low on the frame and the low density air filled electronics housing is set above the central axis. This design means we do not have to use as much buoyancy and ballast to ensure a stable ROV.

Vehicle Component	Mass (grams)	Volume (cm^3)	Density (g/cm^3)	Quantity
Thruster	244	137	1.78	x8
Horizontal motor mount	62	67	.93	x4
Vertical motor mount	89	96	.93	x4
HDPE frame	1360	1402	.97	x1
Electronics housing	2022	3398	.595	x1
Cameras and mounts*	81			x4
Plastic payload tools*	174	187	.93	x1
Servo claw*	141			x1
Tether**	4100			X1
Total	6577	6735	0.97	

*negligible for density calculations

** Tether not included in vehicle density. Mass with tether = 11.3kg

CAMERAS

In order to achieve optimal visibility during product demonstration, we employed four waterproof cameras on our vehicle. We designed waterproof enclosures for each camera that keeps the camera dry on the inside. It is modeled using CAD, and then was 3D-printed. An acrylic lens is attached to the front using a silicon adhesive for a crystal clear view. The cameras are mounted to the frame using a unique ball mount system. This allows us to move our cameras quickly if needed during the mission. The camera signals are sent through the tether in a simple analog form and then run through a passive balun to clarify the signal. The four signals are then run through a multiplexer, which breaks the four signals and displays them on a single screen. By using a multiplexer, the co-pilot is able to enlarge a certain video feed or break them up in different arrangements on the screen.

CUSTOM 3D PRINTED CAMERA HOUSING WITH MOVABLE MOUNT

THRUSTERS

For our vehicle's thrusters, we selected eight 1,250 gallon-per-hour bilge pump motor cartridges due to their low cost, pre-waterproofing, and reliability. We mounted four of them vertically, one on each corner of our vehicle. We chose to use four vertical motors to cut down the time needed for surface trips during the product demonstration. In order to keep our vehicle as compact as possible, our vertical motors are modular and removable, allowing for easy transport for space travel.

CUSTOM 3D PRINTED MOTOR MOUNTS

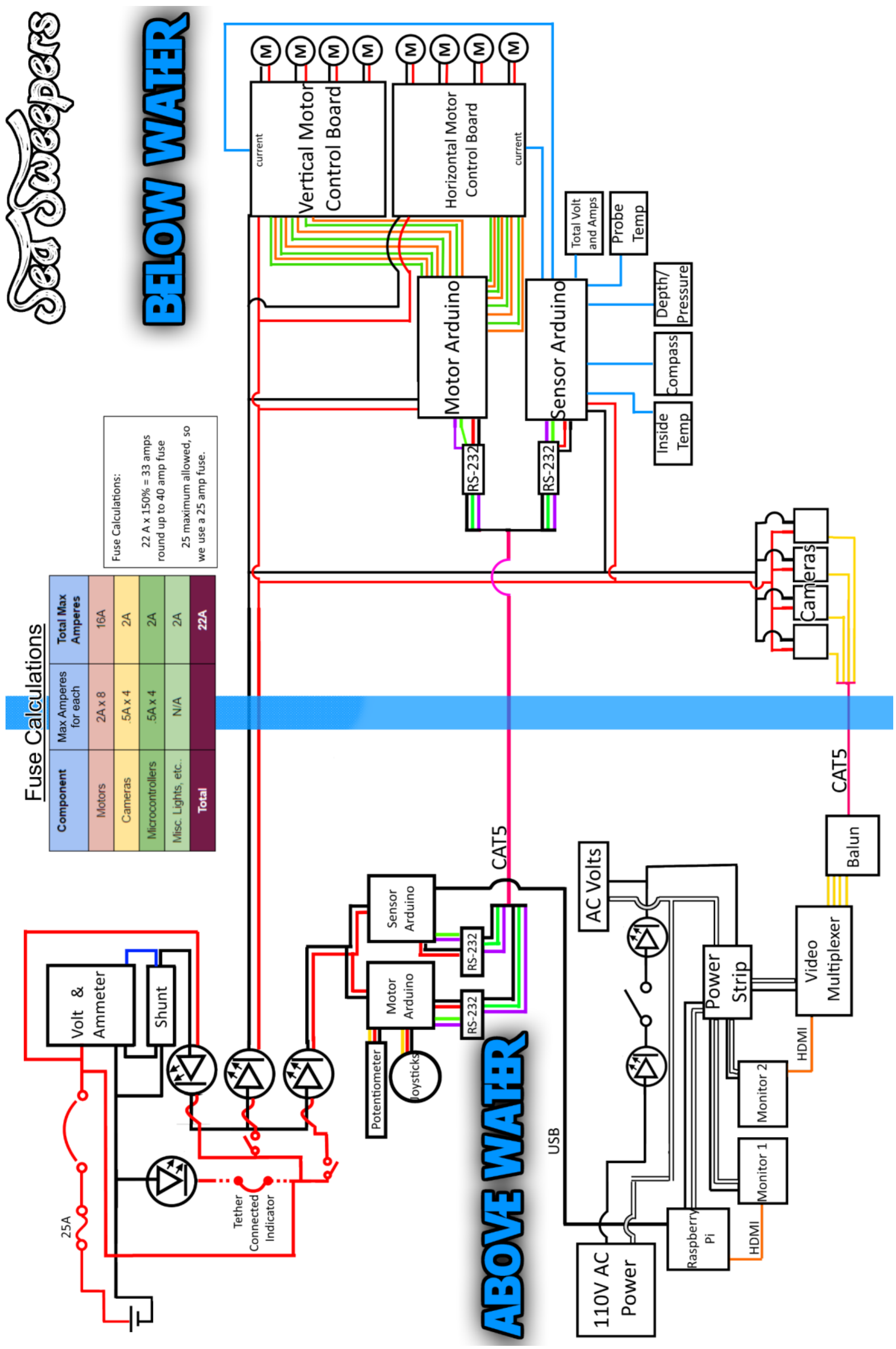
The four horizontal thrusters are placed at the corners and vectored at 45 degrees relative to the central axis of the vehicle. Their position at the four corners of the vehicle makes it very agile and easy to control in both forward and side-to-side maneuvers. Having eight well-placed and powerful thrusters on a light frame makes our ROV able to move in any direction with agility.

Counter-Rotating Propellers

COUNTER ROTATING PROPELLER V. REGULAR PROPELLER

This year, we elected to use counter-rotating propellers throughout our vehicle. We installed counter-rotating props on opposite corners of our vehicle to help with stability. By using the counter-rotating propellers, there is a minimal net torque produced by the motors, keeping the vehicle more stable when operating at high power settings.

SYSTEM INTEGRATION DIAGRAM



Fuse Calculations

Component	Max Amperes for each	Total Max Amperes
Motors	2A x 8	16A
Cameras	.5A x 4	2A
Microcontrollers	.5A x 4	2A
Misc. Lights, etc.	N/A	2A
Total		22A

CENTRAL CONTROL SYSTEM

POWER

Our control box uses a combination of both AC and DC power. We specifically chose to power our Raspberry Pi, monitors, and video system using AC, removing them from our DC amp limit. There are three switches to turn off our DC ROV, DC in, and AC in. These switches allow for independent control of each of the different types of power we are using. With this unique feature, we are capable of safely cutting off power to the ROV while maintaining power in the control box in case of emergency. We have a circuit breaker on our box in order to avoid blowing fuses, which doubles as a main power switch for our control box.

ASSEMBLED CONTROL BOX

MONITORS

This year we decided to create a dual display consisting of our camera views and status displays. We employ two large open frame LED monitors, mounted in a Pelican case. To avoid issues with small and dim screens, we opted for bigger, brighter monitors to allow our pilot to have a clear view of what is going on under the water. The left screen displays our camera views, which shows four camera feeds simultaneously. The right screen displays our telemetry data. We use a single wireless keyboard and trackpad in connection with a USB switch, which allows us to control both monitors with one integrated keyboard and trackpad.

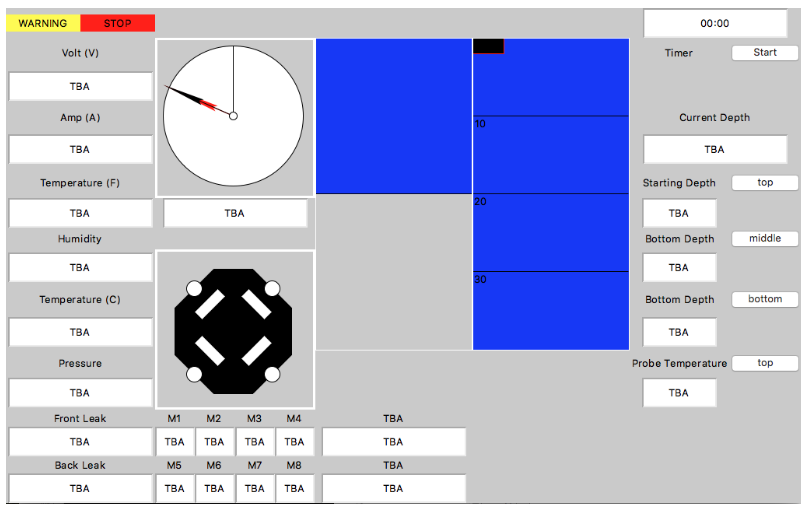
Camera Screen

The left screen in our control box displays our camera signals. We use a "surveillance" style video multiplexer that takes our four video signals and displays them on one screen. This allows us to change the layout of the videos during the mission, and take screenshots. The ability to take screenshots is especially helpful when we have to photograph the coral colonies during the mission.

THE TEAM TESTING THE CAMERAS

Telemetry Screen

The right screen is our status display. The ROV has an Arduino Mega onboard which reads values from many different sensors, including a compass, accelerometer, temperature sensor, depth sensor, and additional sensors for convenience. These values are sent through the RS-232 protocol in the same way our motors are controlled. The bytes sent through the RS-232 are then read and recompiled by an Arduino Uno in the control box. This Arduino Uno sends the information to a Raspberry Pi which is running a Python code to display our sensors' values in an easy-to-read program, which allows our pilot and copilot to closely monitor our system during product demonstrations. The status display also features a leak sensor inside of our tube onboard the vehicle, which we monitor in order to guarantee there are no leaks into the most vital part of our control system.



TELEMETRY SCREEN LAYOUT

THRUSTER CONTROL JOYSTICKS

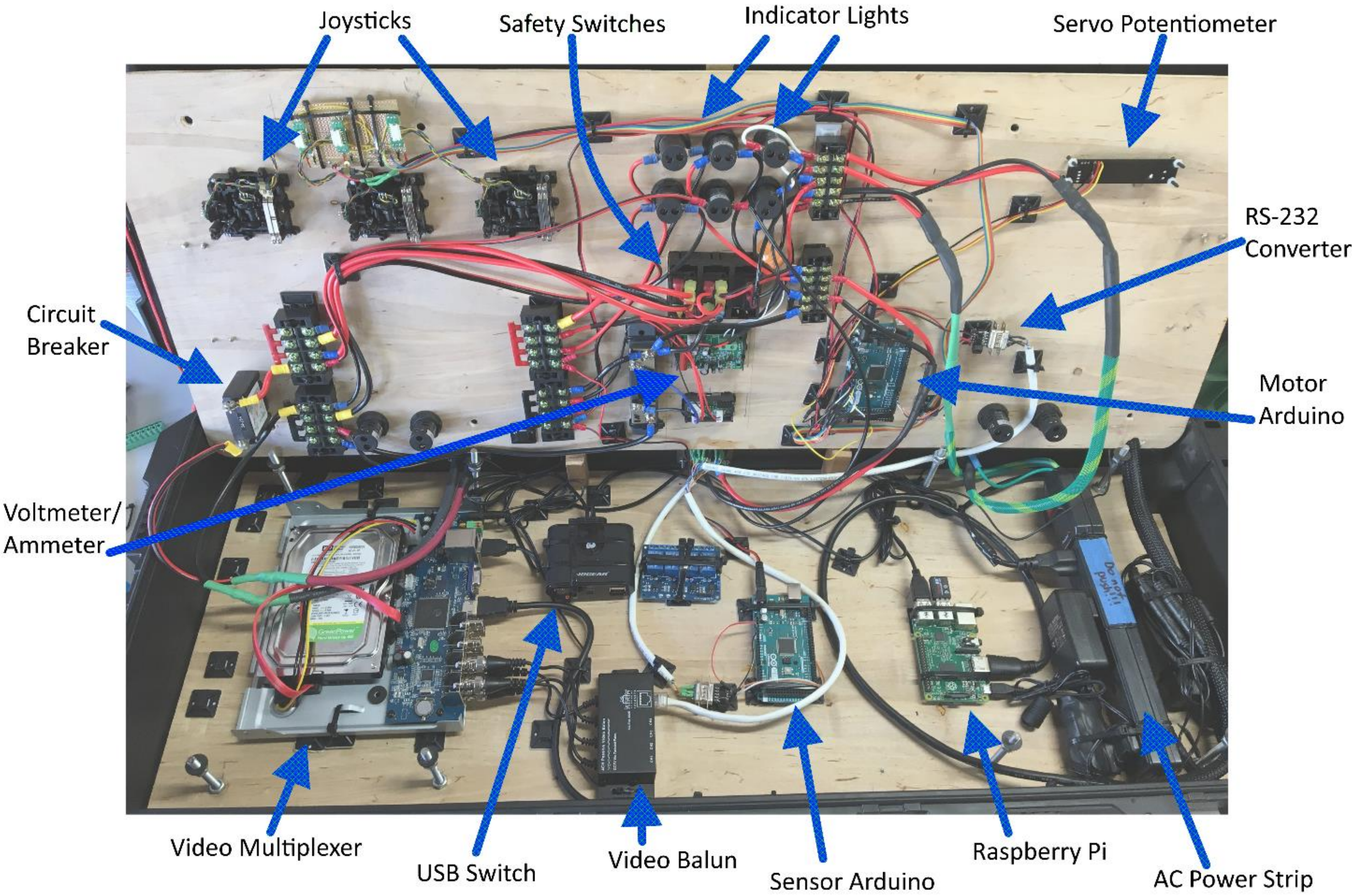
For our control system, we chose to use three two-axis potentiometers, all hooked up to an Arduino Mega in the control box. Based on what our pilot preferred, we assigned each joysticks' values to different motors through our Arduino code. The Arduino consists of converting our potentiometer values into bytes so we can send them long distances through serial communication. In order to achieve the distances needed by our tether, we convert the transistor-transistor logic (TTL) serial into RS-232 signals, which we run at 200,000 bauds. We then send the wires through our tether and we have another Arduino onboard the vehicle. Both Arduinos communicate using a system of checks in order to ensure the bytes being sent are not corrupted or interfered with going through the wire. We have many checksum systems as well as bytes that start and end the transfer in order to guarantee that our potentiometer values are always correct. This bottom-side Arduino reads the bytes that were sent if the checksums and other checks are correct and converts them back to analog values. The code on the bottom-side Arduino then assigns these reassembled bytes to our two four-channel DC motor control boards. The control boards read pulse width modulation from the Arduino to change the speed of the motors, and the Arduino drives additional pins high or low to change the direction of the motors. This is done using our own original code to assign these values accordingly.

THRUSTER CONTROL JOYSTICKS

MISCELLANEOUS CONTROL BOX ITEMS

Our control system utilizes many other features that increase that mission crew's situational awareness during the mission. We have a set of six blue and green LED lights that tell us if our tethers are plugged in and functional. Because we have three connection points going into the control box, each blue light represents one of those connection points. When one of those tethers is connected, the relative blue light will turn on, telling us that particular tether is ready to use. In addition, the green lights tell us when that tether is active. This can be controlled independently by the main switches, and allows us to see if our control box and vehicle are getting power separately.

The pilot and copilot also have their own set of orange and red warning lights in clear view of their respective screens. If our sensors detect something unusual, the red or orange light will trigger depending on the severity of the problem. The problem can further be identified by looking at the telemetry screen. These abnormalities include- but are not limited to- high voltage, high current, unusual temperatures/humidity, and leaks.



VEHICLE ATTACHMENTS

OIL SAMPLE COLLECTOR

One challenge we were faced with was the collection of oil samples. We designed an attachment to retrieve the sample and tried to make it as lightweight and simple as possible. While designing the attachment, we decided that we would make the gap slightly smaller than the sample in order to make the sample secure. We designed the top to be thin enough to flex which allows the attachment to become slightly bigger and securely fasten and retrieve the oil sample.

CUSTOM 3D PRINTED OIL COLLECTOR

SERVO CLAW

A servo controls the claw payload attachment on our vehicle. A servo is a device that uses electrical power and one signal wire in order to act as an electric arm. Our motor control Arduino doubles as a communicator between a potentiometer on the control box and the servo on the vehicle. Using the Arduino, we programmed our servo to move according to the position of the potentiometer on our control box. Our potentiometer is connected to the transmitting Arduino in the control box, which sends bytes that are processed by the receiving Arduino on the vehicle. There is more information on Arduino serial communication in the motor control section of the technical report. The program we designed interprets the receiving position through serial, and then mirrors it to the servo to adjust it to the necessary angle.

SERVO CLAW

ESP ATTACHMENT

There were two challenges we faced with the Environmental Sample Processor (ESP) task when we designed our cable connector attachment. The attachment had to retrieve the cable connector and move it to and then insert it into the power and communications hub. We accomplished retrieval by sliding prongs beneath each side of the cross. We designed these prongs with tapered ends with cupped indents for easy pickup and secure carrying. To keep the cable connector level for simple entry into the port, we designed the fork with a top piece to restrict the short end of the cross from pitching up.

ESP ATTACHMENT

CHALLENGES AND FINANCES

CHALLENGES

Most of the major challenges we faced this year were making executive decisions. We had to work together as a team to research the best options for different aspects of the vehicle, and then discuss the advantages and disadvantages of each part. Often times, we held spirited debates over which parts would be best for the vehicle. When debating, the team would look at the pros and cons of every possibility, and would always decide as a group which option would be the best fit for our vehicle. We debated many topics, such as which motors we should use, what protocol we should use for our camera system, and more. Programming and other team challenges were the most time consuming, but the most beneficial to the team overall.

Brushed versus Brushless motors

The first decision we faced in the beginning of the vehicle design process was the type of motor we wanted to use. Between brushed and brushless motors, the club was divided and debated the advantages and disadvantages of both. In the end, the club agreed to use brushed motors for the familiarity, reliability, and convenience that they provided, due to their small, easily set-up control system and pre-waterproofing.

Analog versus IP

For the camera system, we debated analog versus IP; while IP uses only one Ethernet cord in the tether, significantly reducing the weight of the vehicle and increasing the manageability of the tether, the team decided that IP was not the best fit for our vehicle, and that serial communication and analog would do exactly what we needed to achieve with the least amount of room for error. Our programmers were not familiar with sending packets of information through IP using Arduinos, thus after extensive research, we decided to opt for a more familiar system, serial, in order to maximize the amount of time perfecting the codes, as opposed to spending time learning a new protocol.

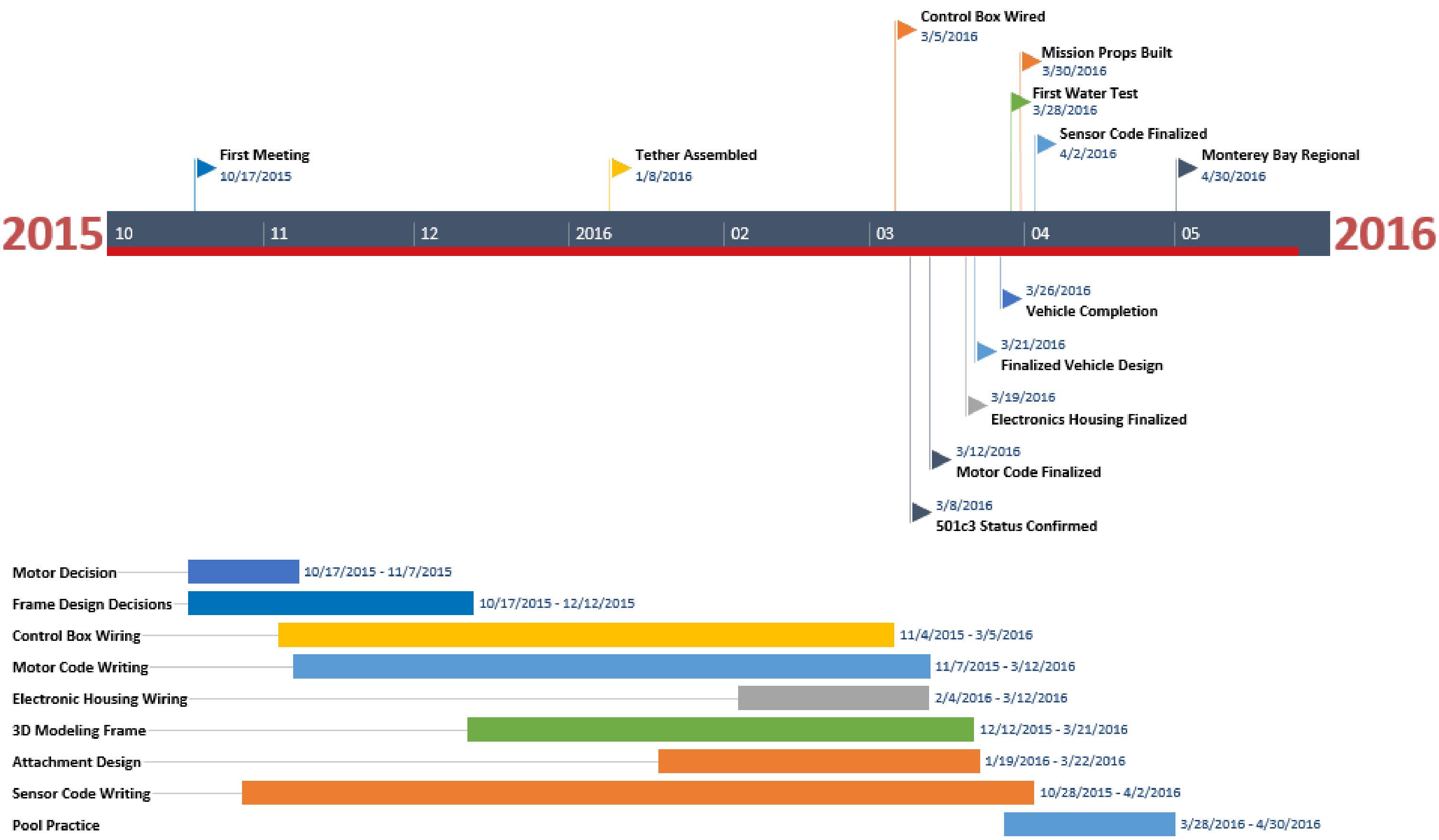
Programming/Coding

Our programming team began the year with little to no experience in programming for Arduino. Michael and Brian, our programming specialists, had to spend time researching how Arduino code works and how it can apply to our ROV. Experimenting with different ways to send the information, they eventually opted to use serial communication and reach the necessary distance by using the RS-232 protocol. Motor control boards were something the team did not decide on at the very beginning. There were two main choices: one that would require learning a new packet protocol for our programmers, but would allow monitors of amp draw, voltage draw, and more, and one that would use the default Arduino digital protocol, but could only measure current; the first being a Pololu motor controller and the second being a Sparkfun motor controller. We debated on the pros and cons, but the ultimate factor was the price. The Pololu motor controller was $55 per motor controller for a total of $440. The Sparkfun motor controller was able to control four motors for each controller that cost $22 each for a total of $44. We were able to get both boards to work, so we chose the Sparkfun controllers because they were more cost efficient.

Non-technical Team Challenges

As a team, the Sea Sweepers faced personal challenges as well as technical challenges. With nine active team members, the biggest issues were scheduling meetings that worked for everyone and keeping everyone occupied with tasks to complete. To overcome this, we delegated tasks to specific team members or groups of members, and then set deadlines to finish these tasks. This way, team members could work at meetings or at home, so no one had to attend every single meeting and we did not have to compromise the team schedule for individuals. In addition, the Sea Sweepers added five new members who had no prior experience in the MATE competition. Because of this, we spent the beginning of the 2016 season teaching new members about the ROV and the mission.

TIMELINE



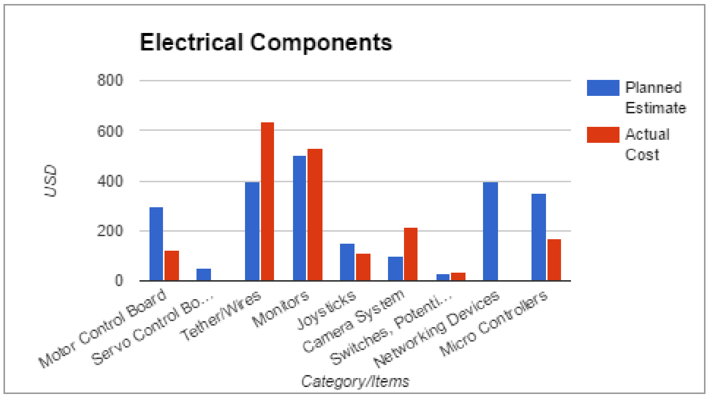
FINANCES

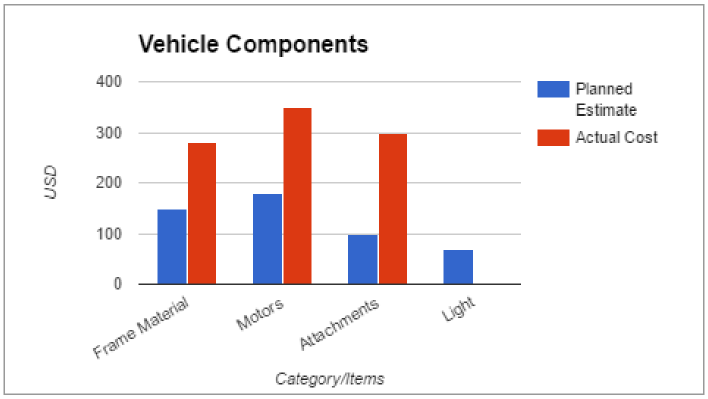
Sea Sweepers 2015-2016 Budget and Expenses (USD)				
Category/Items	**Planned Estimate**	**Actual Cost**	**Actual Variance**	**Donated/Discounts**
Electrical				
Motor Control Board	300	120	180	
Servo Control Board	50	0	50	chose not to use
Tether/Wires	400	634.53	(234.53)	20% discount
Monitors	500	529.98	(29.98)	10% discount
Joysticks	150	113.41	36.59	
Camera System	100	214.36	(114.36)	
Switches, Potentiometers	30	34.25	(4.25)	misc. donated $200
Networking Devices	400	0	400	chose not to use
Micro Controllers	350	172.25	177.75	
Totals	**2280**	**1,818.78**	**461.22**	
Vehicle				
Frame Material	150	281.48	(131.48)	cutting donated ($300)
Motors	180	349.68	(169.68)	
Attachments	100	300	(200)	
Light	70	20	50	
Totals	**500**	**951.16**	**(411.16)**	
Supplies				
Mission Props	300	321	(21)	
Marketing (t-shirts)	300	316.86	(16.86)	shirts discounted 5%
Shop Upgrades	1,200	1,580.81	(380.81)	
Totals	**1,800**	**2,218.67**	**(418.67)**	

Overall Budget Total: $3,490

Estimated Budget: $8,000

Actual Total Spent: $4,988.61





BUDGET/PROJECT COSTING

This season, the team decided to start completely from scratch and attempt to improve all aspects of the vehicle, which meant raising and spending more money than ever before. At the beginning of the season, the club estimated a budget of $8,000, more than doubling the budget from last year. In order to raise the necessary funds, our team reached out to more sponsors early on in the season and worked throughout the year to raise money. Many of our generous sponsors from the past supported us again, along with new companies of greater reputation. In the beginning of the season, we sent out letters and e-mails to possible new benefactors in the hopes of adding new sponsors to our growing list. Then, later on in the season, we returned to our sponsors from past years and asked if they would like to donate again to our cause. Our sponsorship process is very similar to that of last year, with an organized procedure headed by dedicated individual team members. Utilizing a successful letter writing campaign, we raised $9,250, all thanks to our incredibly generous sponsors. With their support, we had peace of mind when buying new parts for broken items. For the first time in team history, we applied to the IRS for 501(c)(3) status to become an official non-profit organization and were confirmed as tax exempt on March 8, 2016.

LESSONS LEARNED/SKILLS GAINED

The 2016 season was a revolutionary year for the Sea Sweepers both in terms of vehicle design and control system complexity. While before we used basic programming, this season we designed our entire control system to be digital; in the process, we learned and practiced many new skills in computer programming and coding on an Arduino platform. Our 3D modeling program, Autodesk Inventor Professional, allowed us to accurately create digital models of vehicle parts and payload tools. This provided us with the opportunity to dramatically improve our design process with new 3D modeling skills. In addition, our system design required us to house on board electronic components in a watertight enclosure; thus, we learned the important lesson that more advanced waterproofing techniques are critical to protect the electronics as well as allowing us to detach the tether from the vehicle via connectors. Overall, we learned to appreciate team cooperation in a group that consisted of individual specialists. Running the club more like a business, the team utilized deadlines and project planning to better manage designing, building, and testing processes.

FUTURE IMPROVEMENTS

In the future, we should try to make important executive decisions earlier on in the season, rather than debating the pros and cons of an issue for too long. Finalizing designs early is hugely significant for saving time and having enough time at the end of the season to test and troubleshoot the vehicle. To improve, we need to decide and finalize our vehicle designs in the beginning of the season and not change our minds halfway through. This would give us more time to practice in the pool, and thus, more peace of mind as the competition draws nearer. Another necessary improvement for the following seasons is improving how we spend our money. This year we unwisely invested and made poor decisions while purchasing items, which is also related to our previous problem of changing our minds on big decisions.

REFLECTION

"My experiences in ROV made me aspire to become a software engineer. Before joining the Sea Sweepers, I had no experience programming in order to solve problems. Due to the challenges our team has faced, however, I have learned to critically solve these challenges and it has made me enjoy being a part of an engineering team. I am now excited to study software engineering in the future."

M. Georgariou
Software Engineer

M. Sprague
Project Manager

"My past year with Sea Sweepers has enhanced my career vision in a number of ways. First, it gave me a glimpse of the difference between learning math and science in the classroom versus real world applications, which we put into use nearly every day – not just in creating and problem solving, but also in putting out fires, literally! Secondly, the experience amply demonstrated that my chosen field of engineering involves far more than just math and science. Without skills like communication, organization, planning, delegating, and team coordination, it doesn't matter what SAT scores you have!"

"This program has been instrumental in choosing my career. Not only was I able to learn how to program on my own, but also to apply the skills I learned to a project… It has inspired me to learn more so we can create more advanced software to benefit the team, to learn more skills that I have not learned in school like wiring and soldering, and most importantly it has taught me how to work with others. We have many different personalities on the team, and this project has taught me invaluable lessons with interpersonal skills. Everyone has a perspective on how to solve a problem, and we have learned to hear everyone's opinions before making decisions. It has spurred growth for each person and ultimately led to a healthy work environment."

B. Ishii
Software Engineer

C. Oleson
3D Modeler

"Most importantly, my ROV experience has taught me how crucial team work and engineering collaboration is to the success of a design. Innovation is achieved through conflicting ideas coming together as one."

After participating in the 2016 season, our team members are better prepared for the workforce, trained in both technical and social aspects. Designing and building the ROV has helped the team achieve excellence in the field of engineering, while the product presentation, sponsorship campaign, and careful budgeting provided us with the business skills necessary for future endeavors. The majority of our team plans on entering the career fields of engineering and science, so participating in the MATE ROV competition has allowed us to fully immerse in and experience the competitive scientific and engineering world. Out of the many years that we have done this, our team members have learned the most this year. We have learned tremendously about electronics and engineering, but also the importance of teamwork. No matter what our outcome in competitions will be, our team has come so far to create an outstanding product, and we have learned invaluable life lessons.

VEHICLE CARE/TROUBLESHOOTING

This season, we took multiple steps to maintain the condition of the vehicle and ensure it is always prepared for use. Because pool water is corrosive, we made it a priority to rinse off every centimeter of the vehicle with fresh water after testing in the pool, protecting the wires so that they remain in prime condition. Also, we carefully roll up our tether onto a custom-made roller. We made this tether hold to eliminate kinks or rips. All of these steps ensure that every time we take out our vehicle, it is set up the same way and ready to use. For troubleshooting, we would start wide and narrow in on the problem. When the whole vehicle system wasn't functioning properly, we would find the system responsible for the error, then test each part of that system until we would find and repair the problem. We would then move back up, testing the part, system, and then the whole vehicle to ensure proper performance.

CLUB SPONSORS/CONTRIBUTORS

The Sea Sweepers owe our success to our generous sponsors; we could not have competed without their support. We have received over $9,000 worth of sponsorships and donations.

There were four levels of sponsorship: Dolphin, Orca, Humpback Whale, and Blue Whale. These were categorized by the amount of money donated and were as follows:

- Dolphin: $100
- Orca: $500
- Humpback Whale: $1000
- Blue Whale: $1500+

Pre- International Competition Sponsors:

Tanimura and Antle	$1,500 - Blue Whale
Associates Logistics	$1,000- Blue Whale
Joe Pavek	$1,000 – Humpback Whale
James O'Dell	$500 - Orca
Streamlife, Inc.	$500 - Orca
Mann Packing Co., Inc.	$500 - Orca
Fabretti & Dedini	$500 - Orca
El Camino Machine & Welding	$500 - Orca
Green Rubber Kennedy Ag	$500 - Orca
Colin & Marianne Horwitz	$500 - Orca
Mr. & Mrs. Oleson	$300 - Dolphin
Brothers Produce	$300 - Dolphin
Church Brothers	$300 - Dolphin
D'Arrigo Bros	$300 - Dolphin
Produce Alliance	$250 - Dolphin
Stillman Sprague	$200 - Dolphin
Kiwanis Club	$200 - Dolphin
Daniel Beringer	$100 - Dolphin
John and Sue Samaro	$100 - Dolphin

Dirty Parts	$100 - Dolphin
Stat! Spray	$100 - Dolphin

Total: $9,250*

*the amounts given reflect the funds raised and expended as of May 26th.

ACKNOWLEDGEMENTS

The Highway 68 ROV Club would like to humbly thank and acknowledge many people who have contributed to our team and made all of our accomplishments possible. The contributions of sponsors, parents, and our mentors have not gone unnoticed to us, and we would like to highlight a few outstanding parties. First, thank you to the MATE organization for hosting this competition and providing the opportunity for students to learn about the many areas of science, technology, engineering, and mathematics career fields that interest us. This competition has challenged us both intellectually and physically, showing us the utmost importance of teamwork and communication. Thank you to the Meadows Homeowners Association for the use of their pool and facilities to test our vehicle. We would also like to thank our families for their commitment, support, and understanding. A huge thank you to our generous sponsors; we are so incredibly appreciative of their financial support to the team, as they make building the vehicle and competing with it possible. Finally, we acknowledge and thank our biggest supporters, Kurt Yeager and Mike Allen, for mentoring us so dutifully and thanklessly. Due to their dedication and support of our endeavors, we owe them the greatest thanks of all.

*All photos taken by JP O'Dell.

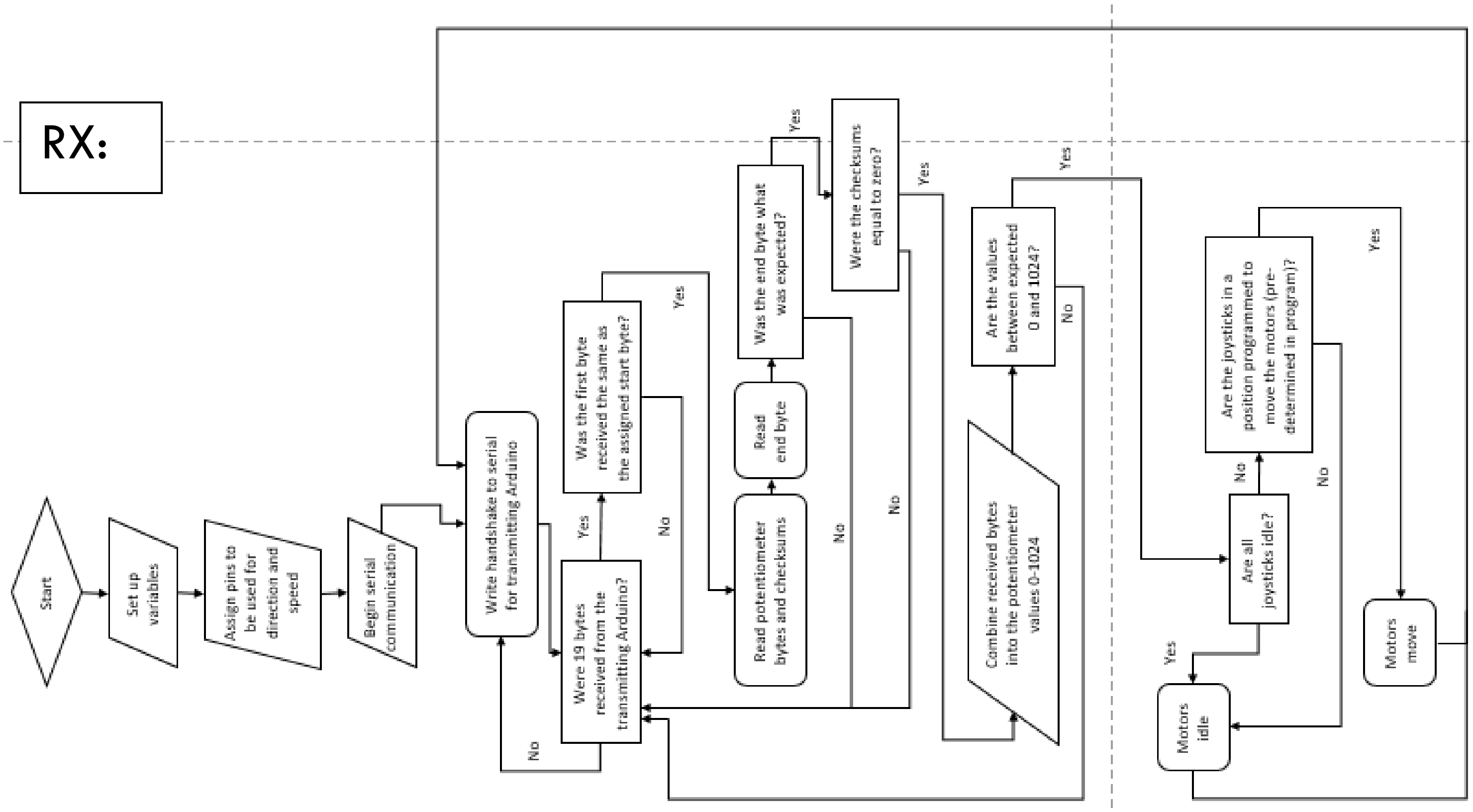
REFERENCES

Chuck Felice, Salinas High School woodshop teacher
James Nichols, Salinas High School drafting teacher
Jim Warwick, Salinas High School vocational teacher
Kevin D'Angelo, Robert Louis Stevenson School robotics teacher
MATE: *http://www.marinetech.org/*
Arduino: *https://www.arduino.cc/*

Sea Sweepers ROV Facebook Page: *https://www.facebook.com/SeaSweepers/*
Sea Sweepers Website: http://seasweepersrov.com

APPENDIX A: MOTOR CONTROL PROGRAM FLOW CHART

RX:



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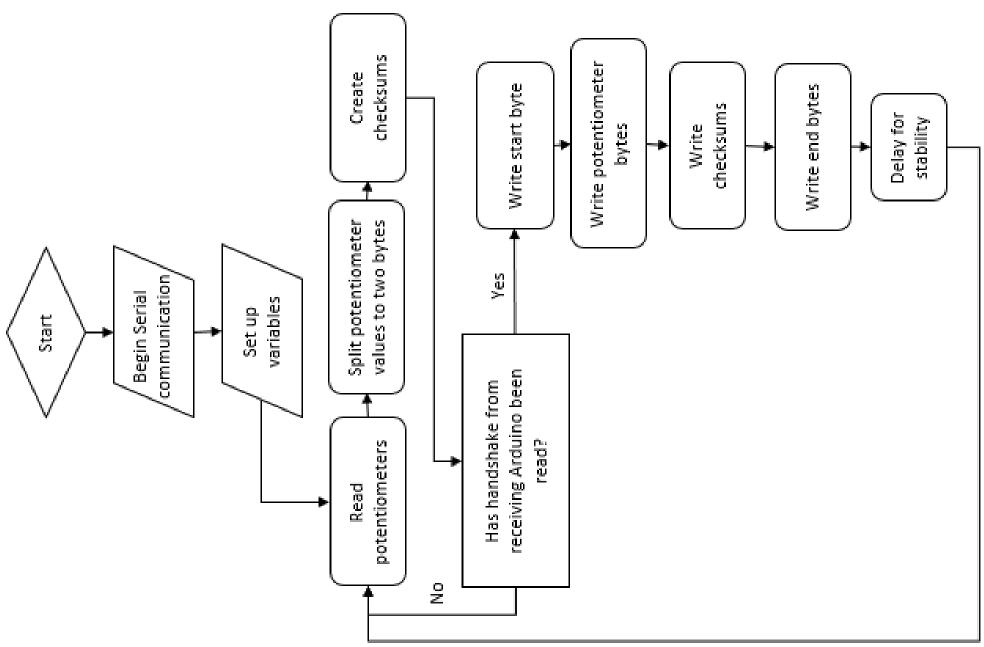

APPENDIX B: SENSOR PROGRAM FLOW CHART