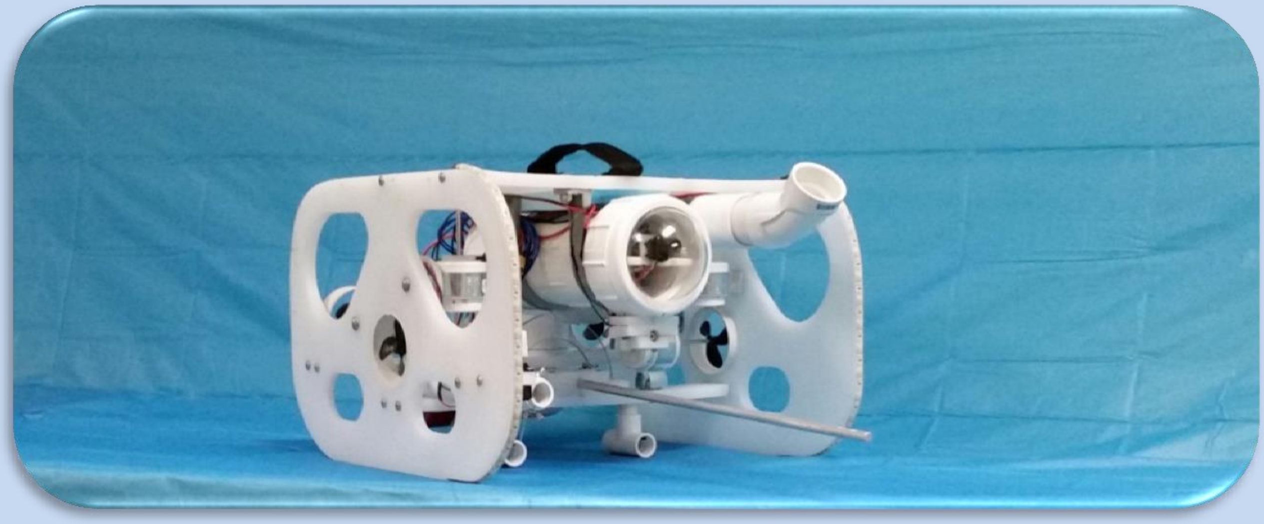
SRCA SubTropics

ROV 3.0



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Abstract

As oil exploration expands into Arctic waters, the need grows for underwater Remotely Operated Vehicles (ROVs) to replace human divers in these challenging conditions. Both to perform commercial tasks and scientific study under the ice, ROVs are the ideal solution to operating in this hostile environment. Upon evaluating the needs of the customer, our company, Santa Rosa SubTropics, has developed our newest model, ROV 3.0. Specifically designed to operate in arctic waters, this submersible craft combines power, maneuverability, excellent field of view, and proprietary tooling to accomplish the tasks required for both commercial and scientific pursuits.

Design Rationale and Vehicle Systems

Frame

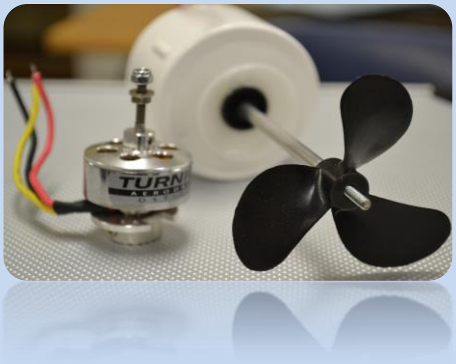
The frame of ROV 3.0 is made out of high density polyethylene (HDPE), and clear Lexan. HDPE was used for the bulk of the frame and was chosen for its low cost, neutral buoyancy, and ability to be easily shaped. The clear Lexan was used for its transparency when a solid structure had to be positioned in front of a camera. Our structure was built using a number of different tools including a scroll saw, drill press, hole saw and other small hand tools. The side panels have circular cutout openings to better assist with the flow of cross currents. We have rounded the corners to cause less drag and for safety when handling. Our LED lights are slightly recessed at the bottom of the frame, allowing the ROV to sit level on the bottom surface without crushing them. The square frame design allows for easy mounting of an assortment of different tools. The frame is mostly symmetrical in design, making it well-balanced in the water.

Electronics enclosure

The electronics enclosure for ROV 3.0 is made from a 3” PVC compression coupler, with an acrylic dome glued on the front. This dome allows wide field of view for the primary camera housed inside. The threaded front end cap was modified on a lathe by two team members to fit the dome. The rear bulkhead is made of HDPE and contains all the through-connectors for the electronics. Held on by a threaded cap, the rear bulkhead is easily removable and allows for ready access to the electronics inside.

Propulsion

The thrusters of ROV 3.0 can each put out 9 ½ newtons of thrust at six amps, and are based on small brushless motors enclosed in housings made of 1.5" pvc caps and plugs. A stainless steel extension shaft passes through a rubber seal glued to the housing and has the propeller attached at the end. Through the testing of different propellers, the team picked Graupner 2308.65 propellers for their ability to have a high thrust with a low amperage requirement. Six thrusters are utilized with two on each axis and are all located at the approximate centerline of the craft. This arrangement allows for good maneuverability and balance.



Thruster

Control System

This control system for ROV 3.0 is designed for two operators and utilizes two commercially available radio controllers generally used for model aircraft with the transmitter modules removed. The trainer ports on the controllers output all the control signals over two wires in PPM (pulse position modulation) format. Down on the ROV at the other end of the tether, two converter chips are used to change the PPM signal to individual PWM (pulse width modulation) outputs to be sent to each motor controller, servo, or other device to be controlled. This system allows us for up to 18 devices to be controlled from two controllers over four very small wires. This allows for a smaller, more flexible tether which aids in maintaining vehicle maneuverability.

Controller

Cameras

ROV 3.0 is equipped with two wide-voltage video cameras with 90 degree fields of view. Able to operate on voltages ranging from 6 to 14 volts, these cameras were selected because they allow us to avoid video black-out due to voltage drop stemming from high electrical loads in other systems of the ROV. The primary camera is mounted behind the dome at the front of the electronics housing and is able to be tilted up and down by a servo. The secondary camera is located at the rear of the ROV pointed down at a 40 degree angle and is housed in a proprietary enclosure made from a ¾" PVC union, 1" PVC cap, and a 9mm thick Lexan lens. Together these two cameras provide excellent visual coverage of the tooling and surrounding areas.

Tether

Our tether is comprised of 15 meters of flexible 10 gauge copper speaker wire and ethernet cable bundled together. The 10 gauge wire was chosen to carry power from the surface power supply to the ROV due to its low resistance and low voltage drop across its length. At the fuse-limited maximum current of 25 amps the voltage drop is 2.5V and at the normal operating current of 12 amps it is a mere 1.2V. The four twisted pair in the ethernet cable provide pathways for the two video and control signals and their twisted orientation is effective in reducing interference from nearby circuits. The tensile strength of our tether was found through testing to be 216kg which gives us a working load of 54kg if we go by the industry standard of 25%. The buoyancy for our tether is provided by 9 cm sections of pipe insulation spread evenly along its length. At the power input end of our tether there is an emergency stop button and 25 amp fuse holder integrated in a single housing. This provides safety for our entire ROV systemand a quick and easy way to shut down power in an emergency.

Tether Testing Stop Box

Tools

Algae Collector/Water flow Attachment

The water pathway tester attachment and the algae collector are a part of the pump system. Both are powered by a 12 volt bilge pump located at the lower rear of the ROV. On the intake end is the algae collector, which we used to pull in the algae sample. This tool is located on the top left of the ROV in plain view of the primary camera. It functions by drawing in the algae sample while the pump is turned on and then allowing it to float back up to the top of the system where it is kept in containment area once the pump is shut off. On the discharge side of the pump is the water pathway tester. By inserting this tool into the input of the pipeline and then activating the pump water is pushed through the pipeline. These tools are easy to operate, and extremely effective.

MPT (Multi-Purpose Tool)

Anchored to our lower cross member is the MPT or multi-purpose tool. It is a forty-three centimeter, rubber-coated, aluminum rod. Aluminum was used for its light weight and was rubber-coated for a higher coefficient of friction to prevent objects from sliding off too easily. Used to collect sea urchins, deploy the acoustic sensor, and for the general manipulation of objects underwater, this tool demonstrates that sometimes the simplest tools are the best.

Anode Tester

Mounted to the water flow attachment, the anode tester has been built to test the anode quickly and has neutral buoyancy so it doesn't affect the trim of the ROV. Constructed of aluminum angle contacts, ¾ inch PVC pipe, a coil spring, HDPE center plate, and two LEDs, the anode tester uses a spring-loaded pivot which allows the tester to flex to contact the anode at various angles. The LEDs on the anode tester are connected to the aluminum angle in such a way as to be polarity nonspecific; this gives the tester the ability to check for voltage on any of the anodes regardless of polarity.

Valve Turning Feet

The valve turning feet are designed to allow the ROV to be capable of turning valves quickly and efficiently. Composed of two ½" PVC tees connected to a transparent Lexan crossbar, the feet are centered at the bottom of the ROV in plain view of the secondary camera. This positioning allows the operator to place ROV 3.0 directly on top of the valves and then turn them in either direction by turning the entire ROV.

Laser Measurements

The laser measurement system is comprised of two lasers (one rotating, and the other stationary) set at a known distance apart, an angle gauge, the ROV's primary camera, and video monitor. Vertical and horizontal lines were drawn on the video monitor to correspond with a known angle field of view for the primary camera. The ends of the object to be measured are aligned with these marks and the distance from the object is then determined by triangulation with the two lasers. Once the distance from the object is known, it's size can be easily calculated through triangulation using the known distance between the lasers as the other side of the right triangle. We chose this system because it is more convenient than putting a ruler on the front of our vehicle, and can measure objects that are bigger than a ruler that we could fit on our ROV.

Flange Tool

The flange tool we will be using for this competition, is for attaching the flanges to the pipeline. We have tool metal rods that hold the bottom of the flanges and we have an actuator on the back connected to a tongue with screws in it to hold the flanges. The screws allow us to let one flange go then we move to are next spot and put the other flange on the opposite side. The Flange tool with be put below our ROV so we can see it from our second camera to do our mission. We also have metal rods that extended out the back that will be holding the gasket we have to put inside the wellhead. We will also attach the lift line to the back of the flange tool, which we have to connect to a corroded section in the water.

Flange tool

Safety

Safety

Safety is the highest priority for the SRCA SubTropics. During construction of ROV 3.0, proper protective equipment and procedures were observed. All use of power tools was overseen by adults, safety glasses and gloves were worn when appropriate, and laser safety glasses were worn when working with our on-board lasers. By following these guidelines, we experienced no accidental injuries.

Safety features are numerous on ROV 3.0 in order to protect the user and those nearby. Shrouded propellers, properly sealed connections, an emergency stop button, laser beam blocker, and a fast-blow 25 amp main power fuse make the use of our product safe and worry-free. When using our ROV, proper safety procedures such as the wearing of close-toed shoes, laser safety glasses, and no loose fitting clothing or long hair, are observed.

Safety Checklist

Physical

1. Wear safety goggles when working with tools
2. No loose clothes/tie long hair back when using power tools.
3. Wear gloves when appropriate
4. Have an adviser when using tools

ROV

1. Make sure items are secure on ROV
2. No sharp edges on the ROV
3. Motors are properly shrouded on ROV
4. Keep hands away from the motors
5. Verify tether strain relief is connected to ROV
6. No loose clothes/long hair tied back when using ROV

Electrical

1. Verify stop button is “off” when power source is connected.
2. Verify 25 amp fuse is installed
3. Verify connections on the ROV are secured

Challenges

As the camera and control systems were being developed we found we were getting crossover between the two camera circuits and the control receiver chips. Ghost images from each camera would appear on the other camera's monitor and erratic output from each receiver control chip would occur when the opposite controller was used. This was determined to be an interference issue in the tether and we had to change the wire type for the signal and control portion of the tether. Switching from alarm wire to Ethernet cable solved the problem due to its twisted pair construction which provides good interference resistance.

Being an extracurricular activity and not part of an official class, finding time for ROV team meetings and workshops was easily one of our largest problems. Athletics, studies, and family obligations all require their share of time and frequently left little time for the team to meet. Ultimately, we found no good solution to this problem and everyone just had to show up when they could and the work was divided into smaller tasks so it could be handled by individuals.

Lessons Learned

Over all we have learned many lessons, and had quite a few experiences. Some the lessons that we have learned are that communication must be clear and concise, cockroaches can't be microwaved, the value of organization, and to work hard.

Skills Gained

All in all we have learned a lot this year. With many new students coming in and many old ones going out, we have become an entirely new team. For the new students the skills that were gained were more than the older students. Some skills that the new students may have learned include but are not limited to: how to solder, work with electronics, program certain aspects of the ROV, use of a scroll saw, drill press and other power tools, as well as working with different kinds of people, using a budget, but most of we learned the value of hard work.

The older more experienced students may have furthered their skills in these departments: working with their hands, working with people, as well as safety skills.

Reflection and Experience

Development of ROV 3.0 was a great learning experience for the team. We learned a lot about wiring, waterproofing, construction techniques and teamwork. Being involved in this competition opened our eyes to careers that we didn't know were there. This experience bettered our knowledge and hands-on ability, and we are thankful to have had the opportunity to have been a part of the team. The pride we felt when our vehicle completed tasks in the competition was very rewarding. Seeing something we made work like it is supposed to creates the greatest feeling in the world.

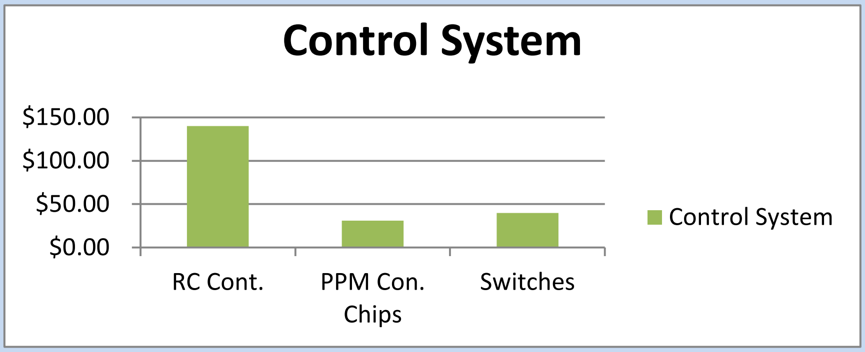
Future Improvements

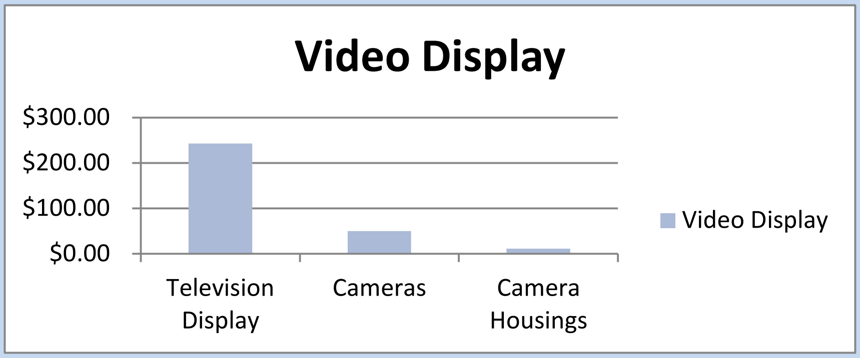
Although satisfied overall with the performance of our newest ROV, we feel that there is room for improvement. The HDPE we used for the frame, while easy to work with, had a tendency to deform and flex. In the future switching to aluminum or a harder plastic may provide more frame stability under load.

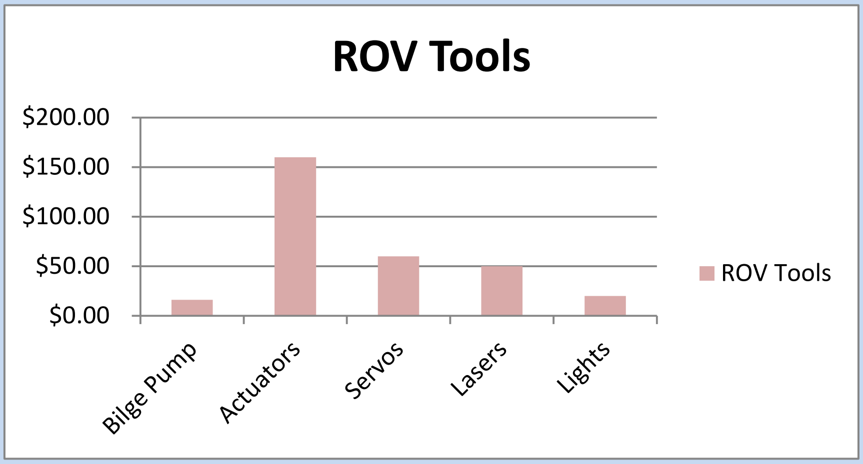
Budget/Project Costing

For our budget, the ROV team estimated the total cost of the ROV instead of separating the project costing into categories. We estimated that the total cost of the ROV would be approximately $2,000.00. Once the entire project was done and we took count of the money spent, we found that the total amount spent was $2,606.00.

RC Cont.	$140.00
PPM Con. Chips	$31.00
Switches	$40.00
Television Display	$243.00
Cameras	$50.00
Camera Housings	$11.00
Bilge Pump	$16.00
Actuators	$160.00
Servos	$60.00
Lasers	$50.00
Lights	$20.00
HDPE Boards	$64.00
3" PVC Compression Fitting	$17.00
3" Acrylic Dome	$9.00
Motors	$54.00
Propellers	$56.00
Speed Controllers	$84.00







Acknowledgements

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- Steve Archer
- Lance Provost
- John Gambold

The SubTropics team would also like to thank all of the following businesses for their support and sponsorship.

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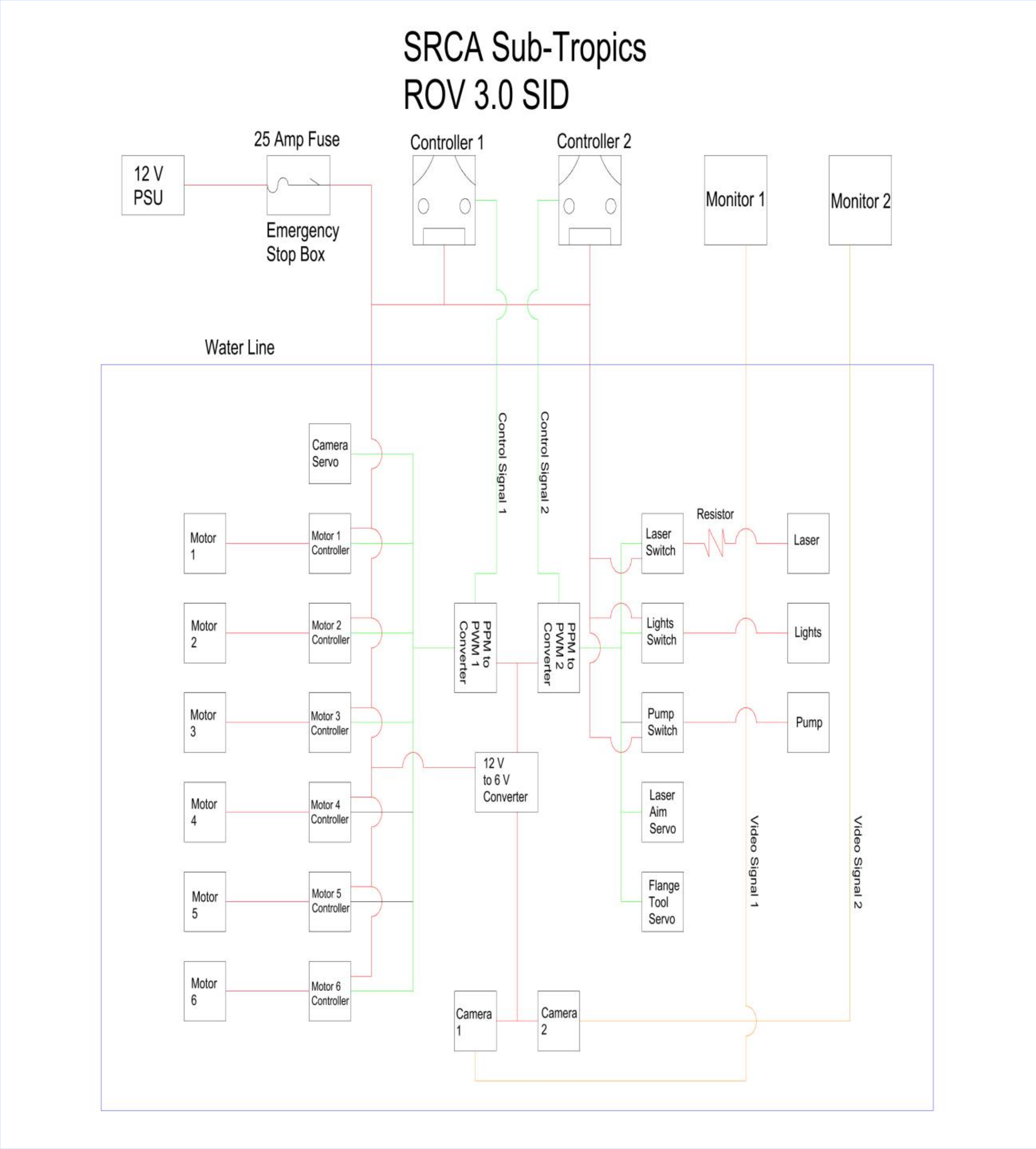
- Watson Family Dentistry
- Cooper Plumbing
- General Rental
- Wal-Mart
- Dunn & Associates
- Truckers USA Enterprises
- King Air Systems Inc.
- Murphy Cassidy Diesel Repair
- Halls Hardware
- Milton Chevrolet
- AIXIZ Lasers
- SCORE Development
- Kyle Holley
- Tractor Supply

SID


SRCA Sub-Tropics
ROV 3.0 SID
25 Amp Fuse
Controller 1
Controller 2
12 V
PSU
Monitor 1
Monitor 2
Emergency
Stop Box
Water Line
Camera
Servo
Control Signal 1
Control Signal 2
Motor
1
Motor 1
Controller
Resistor
Laser
Switch
Laser
Motor
2
Motor 2
Controller
PPM to
PWM 1
Converter
PPM to
PWM 2
Converter
Lights
Switch
Lights
Motor
3
Motor 3
Controller
Pump
Switch
Pump
12 V
to 6 V
Converter
Motor
4
Motor 4
Controller
Laser
Aim
Servo
Video Signal 1
Video Signal 2
Motor
5
Motor 5
Controller
Flange
Tool
Servo
Motor
6
Motor 6
Controller
Camera
1
Camera
2