Waltrip High School Robotics
Houston, Texas
M.A.T.E. 2013 Technical Report

The Completed Rambot

Company Members (from left to right):

Brooke Welch, CCO; Amanda Edwards, CMO; Joseph Townsend, COO; Stephanie "Spoony" Witherspoon, Instructor; Sean Russell, CEO; Andrew Kain, CSO; NayJeah Pridgen, CFO; Jeremiah Miller, CIO; Alyssa Murrell, CTO; Josh Benton, CWO; Tyler Townsend, Mentor

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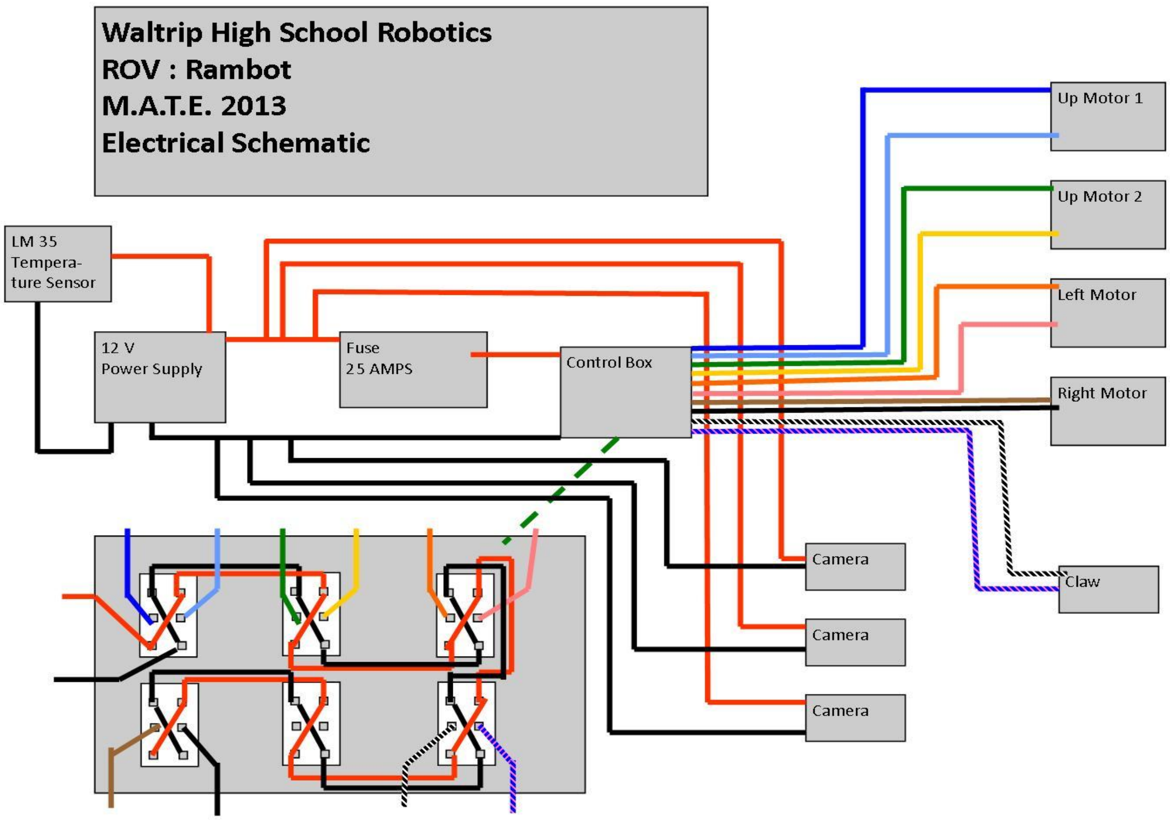
Abstract:

The Waltrip High School MATE team has built, Rambot, a Remotely Operated Vehicle (ROV) that will function to "Take the Pulse of the Ocean" it will do this by being able to service and monitor an ocean observatory. We have dedicated time and effort into Rambot to ensure accurate and efficient results all while keeping things as simple as possible. This simple outlook has allowed us to surpass many complications along the road. We recognize the task at hand and are confident that we will achieve the goals we have set before us. Our ROV will take the temperature of a hydrothermal vent at the bottom of the ocean and deliver or exchange vital equipment to the ocean floor and will keep the ocean safe by removing biofouling from equipment. Our ROV was built to be environmentally safe, to function efficiently, all the while keeping it at a low cost. It was built to conform to all the needs of the real world problems and situations. Our pilots are trained to use the ROV to complete the task quickly and efficiently.

Budget:

Item	Acquisition	Quantity	Cost Per Unit	Total
Multi meter	Donated	1	$40.00	$40.00
PVC pipe 1/2 inch	Purchased	20 feet	1.75 per 10 feet	$3.50
PVC pipe 3/4 inch	Purchased	10 feet	2.25 per 10 feet	$2.25
Various PVC pipe fittings	Purchased	10	$0.50	$5.00
Plastic Dip	Purchased	1 can	$11.00	$11.00
Plastic Spray	Purchased	1 can	$11.00	$11.00
Zip ties	Purchased	12	$0.10	$1.20
Double pole - Double throw switch	Reused	6	$15.00	$90.00
Control box	Reused	1	$12.00	$12.00
Waterproof Video Camera	Reused	2	$115.00	$230.00
Camera monitors	Reused	2	$125.00	$250.00
PVC pipe 1/2 inch	Reused	20 feet	1.75 per 10 feet	$3.50
PVC pipe 3/4 inch	Reused	10 feet	2.25 per 10 feet	$2.25
PVC pipe 3 inch	Reused	4 feet	13.00 per 10 feet	$5.20
PVC pipe 3 inch caps	Reused	4	$4.00	$16.00
Various PVC pipe fittings	Reused	20	$0.50	$10.00
Bilge pump motor	Reused	5	$21.00	$105.00
Wire	Reused	400 feet	$16.00	$64.00
Wire nuts	Reused	24	$0.10	$2.40
Yellow rope	Reused	50 feet	$30.00	$30.00
Lead weights	Reused	40	$0.25	$10.00
Nuts	Reused	16	$0.10	$1.60
Bolts	Reused	4	$0.25	$1.00
Screws	Reused	6	$0.25	$1.50
Hose Clamps	Reused	5	$0.40	$2.00
All thread	Reused	2 feet	$4.00	$4.00
Metal rod	Scavenged	6 feet	5.00 per 2 feet	$15.00
			Total	**$929.40**



Electrical Schematic: Below is our electrical schematic for the Rambot. We have a 25 amp fuse n the positive wire; this fuse is located close to our control box so that if there is a short it will reach the fuse fast and so that it won't reach any other components on the ROV and short them out or damage them. We have the ability to have up to three cameras the wires for the cameras run along the outside of our tether and are zip tied to the tether so that they can be easily accessed and plugged into our power supply. We have two banana clips that plug into the power supply for our main power supply to the ROV. The three cameras plug into the monitors and the monitors plug into our main power supply to give them power. We have all of our motors and other electrical components connected to the tether so they get all of their power from the main power supply. We also have a temperature sensor that is delivered by the ROV and sits over the hydrothermal vent the thermometer has its own tether and is powered from the Vernier LabQuest.

Design Rationale:

The design rationale for our ROV and solving tasks was to follow the K.I.S.S. principal "Keep it Simple Students" we did this primarily because our coach is new to M.A.T.E. and all but one member of our team is new as well so we thought it would be wise to keep things simple. We are reusing the ROV chassis that was used by the previous team and we added some simple fixed structures to interact with the props in order to solve this year's tasks. Although we repurposed the ROV from last year there was still plenty to do we had to fix multiple pars of the ROV. The gripper was basically destroyed traveling home from Florida and the wiring was a mess it had been changed so many times that it had many short splices in it that need to be repaired. Next we replaced PVC pipe that was either damaged or missing from the ROV.

Frame and Buoyancy:

Rambot's frame is constructed out of PVC pipe which was ideal for our needs and functions. We chose to use PVC on the ROV because it is inexpensive, it is lightweight, it is easy to work with and it can be used for buoyancy or to put weights on all-thread on the corners of the ROV or into the pipes to make the ROV heavier.

We used sealed 3" PVC pipes for our buoyancy. In order to keep our ROV neutrally buoyant we added lead weights on the four corners of the framework and inside some of the PVC pipe of the ROV.

Top: Rambot's ballast for buoyancy made from 3" sealed PVC pipe
Bottom: Lead weights on frame to add mass

Control System:

The control system we use consists of double pole – double throw switches that connect to the power supply through a 25 amp fuse that is in the positive power supply wire. We did this because it is the safest way for our robot to operate if there happens to be a malfunction or short the fuse will blow and this will stop the ROV immediately and prevent further damage from occurring. We decided to keep following the K.I.S.S. principal on our control system because we realized that the more complicated and or high-tech you make this system the higher the percentage of a malfunction occurring and when that happens our attention to completing the task is reduced as our attention turns to how to fix the issue and this uses up valuable mission time. We did however research Arduino and Maestro control systems and motor controllers which can use a Play station 2 controller instead of a switch box which would bring our ROV into more current time from the "Prehistoric Age" which is where our switch box should be.

Rambot control box with double pole – double throw switches

Gripper:

The gripper is an original design that the team created last year that we decided to reuse this season, in order to do this we had to rebuild the gripper because it was torn apart in transit from last year's competition. The gripper uses a bilge pump motor, an all-thread pipe attached to the motor, some stretchable cord, and two arms constructed out of quarter inch plastic sheeting that we cut the shape of the arms out of.

Rambot Gripper powered by a bilge motor allowing for open and closed positions

We designed the gripper so that when the motor is turned it will spin the all thread which tightens the cord and pulls both arms together. We managed this by drilling a hole through the center of the all-thread and then drilling a hole in each of the arms and then running a stretchable cord through the hole in the all-thread and then tying it to each arm so that when the motor is turned the cord will wrap around the all-thread and pull the two arms together making them meet in the middle and therefore giving a gripper motion. At the back of the gripper are two bars linked together at their base with a stretchable cord so that when the motor is reversed and unwinds the cord on the bars pulls them and the bars straighten out and this will force the gripper back open making it ready to close around the next item.

Cameras: We will have three underwater video cameras; one camera was recently damaged and will be replaced. These cameras are fixed in their position to make it easier to drive the robot and pick the direction we need to go in to complete each underwater task. Each camera view is visible from video screens by the driver. With three cameras we are able to have one camera that is positioned above the robot and facing forward and down to give a great view of where the ROV is headed and two additional cameras allow for close up views of the gripper and the fixed manipulating arm.

Top: Rambot camera mounted above ROV gives view of where ROV is headed
Bottom: camera positioned to view arm

Other ROV attachment: The ROV is also equipped with a fixed manipulating arm with removable cross piece that can be used to push, pull or prod items into place.

Rambot fixed manipulating arm with removable cross piece

Propulsion:

The ROV has four bilge motors that have been fitted with propellers for thrust. Two motors move the ROV forward, backward, left and right. The other two move the ROV up and down. These motors allow the driver to control the movement of the ROV in a practical, easy way. We placed the motors in the locations they're in so that they wouldn't interfere with anything else on the ROV. The two side motors locations allow the robot to make tight turns which makes maneuvering underwater easier. The two motors that move the ROV up and down are in locations where there is nothing above or below them which allow for motors to give the ROV maximum power for making it either ascend or descend in the water. The outer shell of each propeller is made out of PVC housing. The PVC housings are 3 inches in diameter and are used to increase thrust and create a safety barrier for the props.

Top: Bilge motor with propeller Bottom: bilge motor with protective housing

Sensors:

At the regional competition we used an LM35 sensor for taking the temperature of the hydrothermal vent the sensor was taken down and put in place by the ROV. The LM35 was soldered to CAT 5 wire with a resistor and a water proof housing was made from a copper pipe and fish tank silicone. The LM35 temperature sensor was connected to a voltmeter and the voltage output could be converted to degrees Celsius using a chart. After the Texas regional it was discovered that our campus science department had a Vernier LabQuest and a waterproof extra long temperature probe that they would allow us to check out. So for the international competition the ROV will take the temperature of the hydrothermal vent with this instead of the LM35 sensor. While the LM35 worked it was very time consuming to convert the voltmeter readings into degrees Celsius. A bonus to the Vernier LabQuest is it will also graph our results.

Extra long temperature probe with Vernier LabQuest

Challenges and lessons learned:

We have experienced many challenges this year and by overcoming these challenges we have learned much. We have a new coach that is not completely familiar with M.A.T.E., only one member of last year's team returned, our principal resigned, other school personnel moved on to new schools and our pool is closed for construction. Luckily we did have one returning member from last year and a coach that has done robotics so while we got off to a very slow and late start this season, we all pulled together and learned together while this did cause some frustrations in the beginning it has resulted in a very tight team. Losing several supportive administrators has been difficult to overcome and we are still working of this but we are very hopeful that our first place finish at regional will go a long way to building support from our new administrators. Not having a pool available at school was very difficult to solve, but we have a team member who has a pool and his family welcomed us into their home and allowed us unfettered access to their pool and home. Having access to this pool was essential to our success but having to travel to an offsite location was very difficult since most of the team does not drive and our coach drives an Aveo (really small car) in addition the time to get to the pool was time lost from working on the ROV. There was one other unforeseen issue with an offsite pool, the atmosphere at a private pool is not exactly a working atmosphere and it was difficult to stay focused when work needed to get done. Another challenge we have faced this year is that we were trying more competitions than we have in previous years so we have had to change the amount of time we had to work on our ROV to work on other objects and robots for different competitions. We have also faced the challenge of money. Our budget has been very limited due to our Districts shortage, which means we have had to find alternatives; such as fundraising and sponsors. We have been selling chocolate bars every Monday after school; we are holding a bowling ball raffle at one of our team members Bowling alleys. We also have gone to many local businesses and asked them to donate and or sponsor us. We have learned that we can overcome any challenge that is put in front of us as long as we communicate and work as a team. Keep calm and ROV on.

Safety

We have several safety features inside of our ROV, first we have a 25A fuse built into the positive wire for the tether so that it will automatically blow if there is too much power. We also have covers on our motors that keep items from getting caught inside and getting tangled in the motor. The covers increase the propulsion on our robot so it is a multi functional purpose item. All sharp edges have been rounded off and any cut off bolts have been filed smooth and covered with electrical tape so that they will not cut anyone handling the ROV.

Troubleshooting Technique:

We have only been in the water with our ROV for a few weeks and we have been trouble shooting one problem at a time. At regional we had a team member make a list during our debriefing after our first run. We discussed each issue and then prioritized the issues and divided the team to work on two problems at a time. Using this method we were able to fix multiple issues very quickly and we were able to improve our score greatly.

Future Improvements:

We worked on waterproofing a command servo and in the future now that we know how to do this we would like to add servos to our ROV instead of relying solely on bilge motors. We would either like to change our ROV control from switches to a joystick which we have purchased but did not get installed or we may switch to an Arduino system and it is possible that we may do both and have a hybrid system. Research we have done this year has led us to decide to try to upgrade to the Arduino system next year so that we can become more technically advanced with our ROV. In the fall we are going to purchase the materials we need to switch to Arduino and we will use the off season and our old ROV to experiment and explore with this new control system and if we like it and feel that it is an improvement to our ROV's abilities we will keep it. We want to make the ROV more universal at doing different objectives by adding arms that can move, bend, or turn so that it can be used for more tasks.

Reflections on the experience:

We have a great team of students that is developing into an outstanding team. Our lead people including our CEO and coach, need to be able to delegate tasks to our team and these task need to be completed in a timely manner, while at the beginning of the season this was not the case as we have progressed through this season it is becoming the norm. We have made improvements in our teamwork over the course of the M.A.T.E. competition; we have learned to communicate with one another more efficiently and learned how to put our heads together to accomplish a "bump in the road" fast and effectively.

Acknowledgements:

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Books:

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Professional Advice:

Chris and Rick Managers from Electronics Part Outlet (EPO)