Recount Inc. Pte. Ltd.

ORCHID II

TECHNICAL REPORT

Singapore American School

Singapore, Singapore

Company Members:

- William Whalen-bridge - returning member, co-CEO, Grade 11
- Dongi Min - new member, co-CEO, Grade 11
- Bharath Srivatsan - new member, CAO, Grade 11
- Jack Lin - new member, COO, Grade 11
- Felicity Dunbar - returning member, Chief Artist, Grade 12
- Shane Rozen-Levy - new member, Head Designer, Grade 11
- John King - new member, Pilot, Grade 11
- Kartikye Mittal - new member, Director of Construction, Grade 9
- TJ Kim - new member, Mechanical Engineer, Grade 11
- Edith Enright - returning member, Mechanical Engineer, Grade 11
- Emily Hall - new member, Designer/Artist, Grade 11
- Alexandre Roche - new member, Artist, Grade 12
- Jason Woo - new member, Theoretical Designer, Grade 11
- Jacob Goldwax - new member, Outside Consultant, Grade 11
- Winston Yoo - new member, Mechanical Engineer, Grade 11

Teacher Mentors: Bart Millar and Meredith White

Table of Contents:

Abstract ---------- 3

Safety Report ---------- 4

ROV CAD Models ---------- 5

ROV Details ---------- 6

Budget/Expense Sheet ---------- 6

Electrical Schematics ---------- 7

Software Block Diagram ---------- 8

Design Rationale ---------- 8

Challenges Faced ---------- 11

Lessons Learned ---------- 13

Lessons from Hong Kong ---------- 14

Troubleshooting ---------- 15

Future Improvements ---------- 16

Reflections ---------- 18

References ---------- 19

Acknowledgements ---------- 20

Appendix 1: Safety Checklist

Appendix 2: ROV Operation Manual

Appendix 3: Temperature Sensor Operation Manual

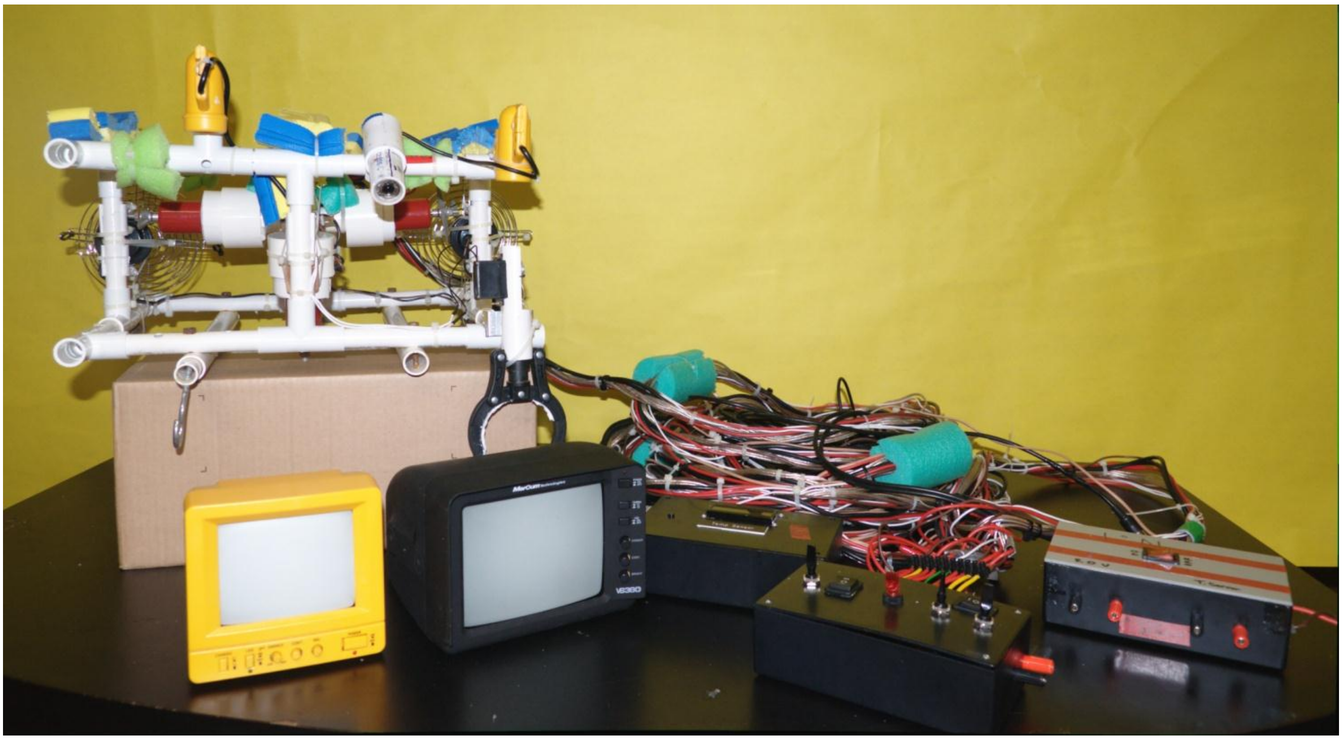
Abstract:

The Orchid II is a powerful submersible capable of performing complicated tasks and maneuvers underwater that is constructed by Recount Inc. The submersible is built to complete parts of all four tasks in the 2013 MATE rover competition, as it is able to take temperature measurements over time from remote underwater thermal vents, remove biofouling from underwater components, replace the Acoustic Doppler Current Profiler (ADCP) on a mooring platform, and install a scientific instrument onto the seafloor.

Within the ROV itself, there are two major groups of components. One cluster consists of mechanisms that enable the robot to perform mission-critical jobs. These parts include a hook and a claw. Both of these tools were carefully planned and constructed with the overall robot design in mind to ensure cohesive fit and function

The other set of machinery includes motors, cameras, floatation devices, and other parts that are necessary for the robot's basic operations. In procuring and installing these elements, our goal was to create a long lasting, durable robot that could survive in difficult conditions.

The robot as a whole rests within a small shell to ensure maneuverability and agility but has high powered motors that can foster effectiveness and strength. Affordable yet powerful, the Orchid II is perfectly suited to accomplishing the tasks at hand.



A complete view of the Orchid II, along with tether, project boxes, and monitors.

Safety Report:

Team Safety Philosophy:

Safety is our first priority, and as such Recount Inc. takes extreme care to be as safe as possible, especially when it comes to using heavy machinery or working with potentially dangerous components. We on the team always warn others in the room when turning on machinery or working on processes like soldering. On the linoleum (in the part of the classroom where our mechanical and electrical engineers work on the robot's different components), we require that students wear safety goggles and other relevant safety tools like gloves. We also have no-food areas in our workshop to ensure good hygiene and cleanliness. After each day's work session, we make sure to clean up what we take out and replace tools to their respective work tables to increase efficiency and safety (by putting away potentially dangerous hand tools and parts). Without proper training, we do not allow our members to use potentially dangerous tools.

Recount Inc.'s ROVs are designed modularly. This allows for enhanced safety because it allows for easy replacement of tools that may be safety hazards if continuously used. The design allows us to more efficiently pick out these potential threats because of the removability of each part (allowing easy testing). Finally, the modular design allows a clean workspace, thereby limiting tripping hazards, miswiring for the electronics, and all sorts of other potential threats.

Shane Rozen-Levy carefully using the bandsaw

Safety Features of the ROV:

Our ROV comes complete with a plethora of safety features that can help us be safe while we work on and test out the robot. For example, all motors are designed to be self contained within the bot to minimize the chance of extruding propellers being able to cause injury. For the forward motors, whose propellers extend slightly out from the frame, fan grills have been used as guards for the propellers. Furthermore, in order to prevent the vertical thrusters from being damaged when the bot touches the ground (due to their positioning, they could be harmed by harsh usage), we've added skids to the robot that can relieve some of the stress of landing.

In terms of electronics, Recount Inc. understands that these robots will be performing underwater in a civilian pool and therefore we have done everything possible to reduce the danger to others. For example, stress loops have been created for all terminal wires on the tether to prevent solder joints from being yanked out during usage by accident or during drive sessions. Furthermore, Recount Inc. has made a team decision to use 20 ampere fuses rather than the official limit of 25 amperes. Extensive testing has shown that our bot never draws more than 10 Amperes.

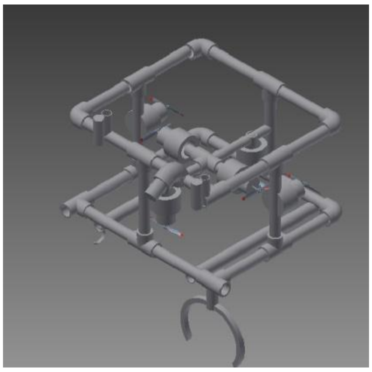
After our Hong Kong regional, we learned about protecting all exposed wires (even those by the poolside) in order to stay safe in the event of rain or sudden water splashes from the pool. Thus, all terminal wiring for the tether and the power goes to self contained project boxes that are splash-proof. Furthermore, we've protected the temperature sensor by giving it a project box of its own while also using fuses for the whole system rather than just for the tether.

Safety Precautions for Handling Robot:

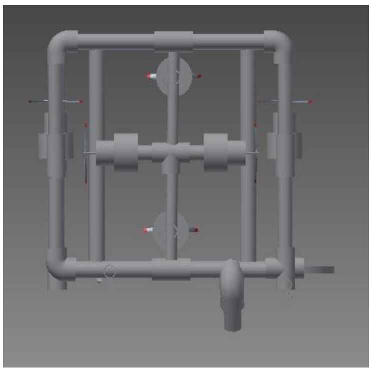
When handling the robot, we take utmost care to protect both ourselves and others. Our most fundamental rule is that the driver/operator is not allowed to touch any switch before hearing the word "clear" from the tether managers. This protects our extremities from harm as we transport the robot to and from our cart. Other precautions include giving one tether manager the roles of watching the safety tethers (we have non-electrical tethers attached to both our robot and our temperature sensor) because this role is of utmost importance in terms of robot protection.

Furthermore, no work is done on the robot without unplugging the power first, just in case. Quick troubleshooting jobs, no matter how brief, are always relayed to the driver first who unplugs the power before permitting the other operators to continue with their tasks. Finally, we make sure to wash off our robot after each use to prevent corrosion that could later cause harm to the robot and ourselves. More specific safety precautions are listed on our safety checklist (attached as an appendix due to its standalone nature).

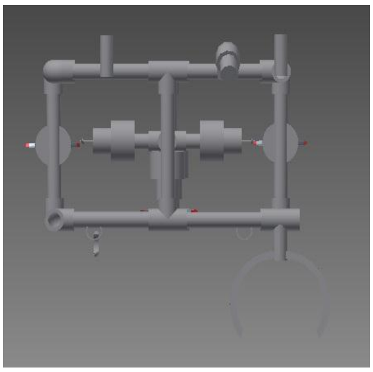
ROV CAD Models:



Angled view



Top view



Side view

ROV Details:

- Name: Orchid II
- Primary Materials: PVC (used in piping), acrylic, kickboard (floatation material)
- Dimensions: 0.40 m x 0.45 m x 0.49 m
- Weight: 5.3 kg

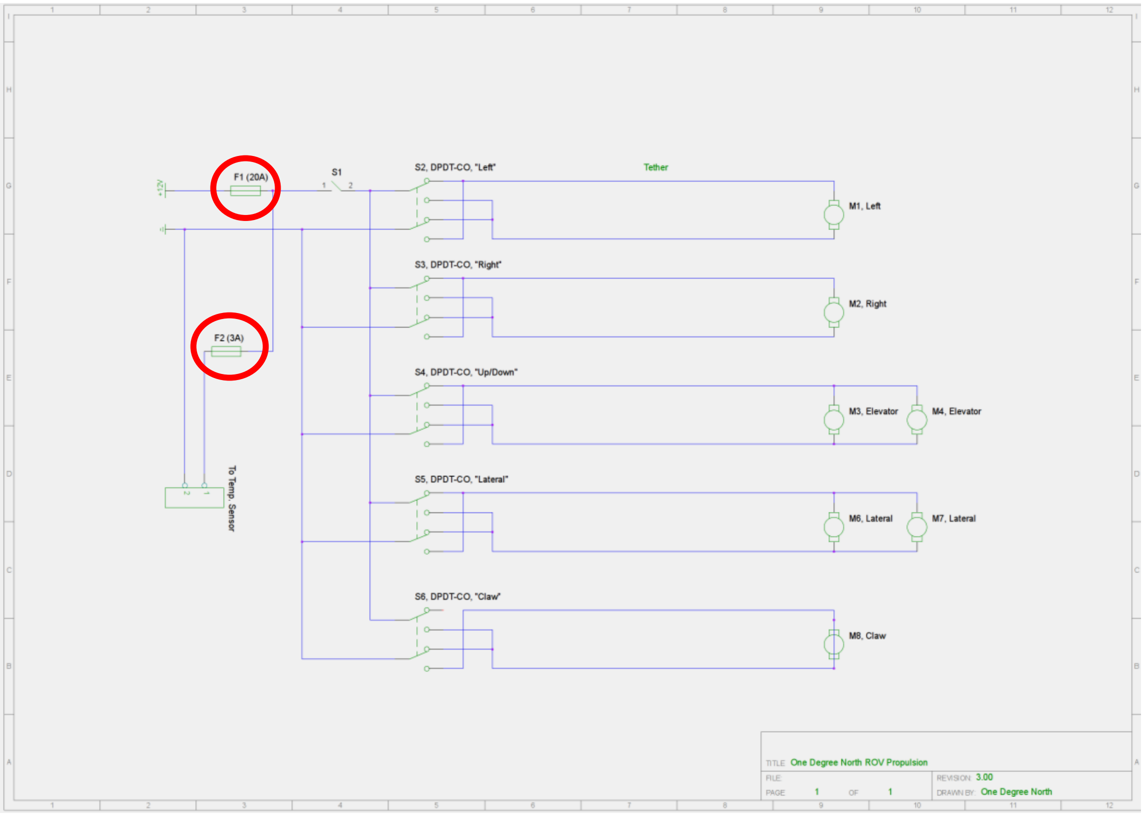
Budget/Expense Sheet:

Part Name/Subsystem	Purpose	Amount	Cost per Unit	Total Cost
Robot Frame				
1-Inch PVC Pipe	Acts as Frame	3.88 meters	$3.50	$13.58
1-Inch PVC Right Angle	Connecting 1/2-Inch PVC pipe	4 piece(s)	$0.50	$2.00
1-Inch PVC Tee	Connecting 1/2-Inch PVC pipe	19 piece(s)	$0.75	$14.25
Quarter Inch Bolt	Connecting 1/2-Inch PVC pipe	2 piece(s)	$0.50	$1.00
Quarter Inch Nut	Connecting 1/2-Inch PVC pipe	2 piece(s)	$0.50	$1.00
				$31.83
Payload Carriers				
Screw Hook	Carrying Payload	1 piece(s)	$0.75	$0.75
1-Inch PVC Pipe	Mounting Claw	0.12 meters	$3.50	$0.42
Parallax Continuous Servo	Closing Claw	1 piece(s)	$13.00	$13.00
Servo Horn	Closing Claw	1 piece(s)	$0.50	$0.50
Spring	Opening Claw	2 piece(s)	$0.25	$0.50
Trash Claw	Carrying Payload	1 piece(s)	$25.00	$25.00
Tetrix Servo Mount	Mounting Claw	1 piece(s)	$5.00	$5.00
13 Gauge Wire	Controlling Claw	30 meters	$1.00	$30.00
				$75.17
Vision System				
Water Proof Camera	Vision	2 piece(s)	$50.00	$100.00
Back Up Camera	Vision	1 piece(s)	$26.00	$26.00
1-Inch PVC	Waterproofing Camera	0.10 meters	$3.75	$0.38
1-Inch PVC Tee	Mounting Camera	1 piece(s)	$0.75	$0.75
Camera Cable	Transmitting Signal	45 meters	$1.00	$45.00
CRT TV	Vision	2 piece(s)	$30.00	$60.00
				$232.13
Propulsion and Control System				
Bilge Pumps	Movement	6 piece(s)	$80.00	$480.00
10 Gauge Wire	Carrying Signal	120 meters	$0.50	$60.00
3 Way Switch	Controlling Motor	4 piece(s)	$4.00	$16.00
Power Switch	Controlling Power	1 piece(s)	$2.00	$2.00
Crimps	Connecting Wire	28 piece(s)	$0.05	$1.40
Fan Guards	Propeller Guards	4 piece(s)	$1.00	$4.00
3-Inch to 1-Inch PVC Pipe	Mounting Bilge Pumps	4 piece(s)	$1.00	$4.00
				$567.40
Ballast				
Kickboard	Flotation	1 piece(s)	$15.00	$15.00
Noodle	Flotation	1 piece(s)	$5.00	$5.00
Rebar	Weight	0.40 meters	$5.00	$2.00
				$22.00
Temperature Sensor				
LCD Display	Displaying Information	1 piece	$15.00	$15.00
Arduino	Processing Information	1 piece	$38.00	$38.00
Temperature Sensor	Getting Temperature	1 piece	$3.00	$3.00
Speaker	Informing Driver When to Take Reading	1 piece	$2.00	$2.00
Funnel	Mounting Temperature Sensor	1 piece	$5.00	$5.00
PWM Cable	Transferring Data	15 meters	$1.00	$15.00
				$78.00

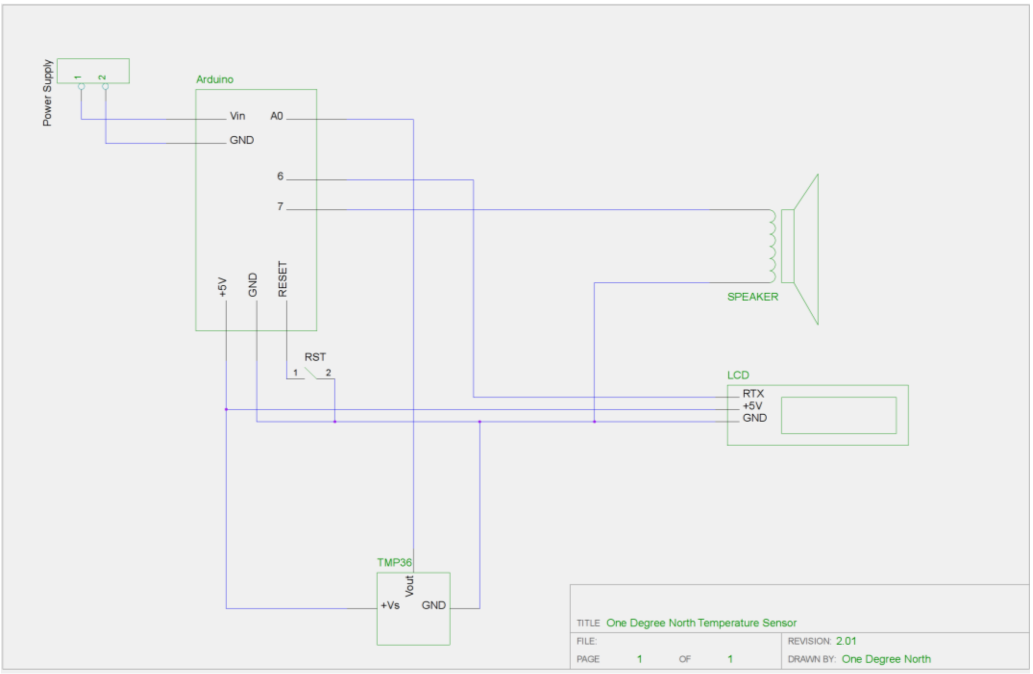
Total Expenses: S$1,006.53 SGD

All funds to cover expenses graciously donated to the Recount Inc. team by the Singapore American School Foundation. Some parts reused from last year's team.

Electrical Schematics:



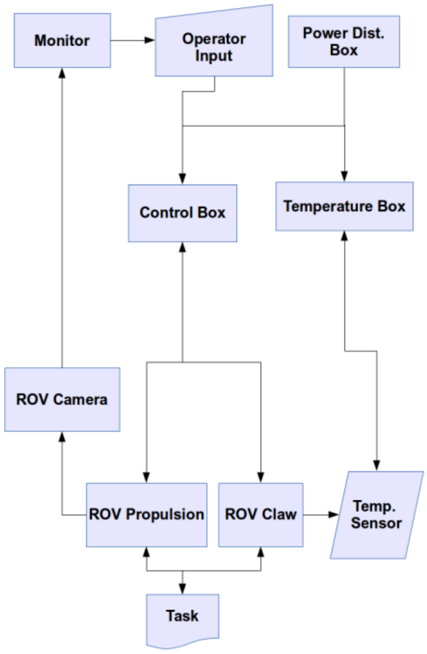
This electrical schematic deals with the propulsion subsystem, detailing the positioning of the batteries, the fuses, the master switch, and the positioning of each motor across the tether. The fuses have been circled in red.



This schematic represents the circuitry of the thermo-sensor. With its own tether (as it must be deployed in a separate location), this schematic details the connection of the transistor itself to the Arduino and ultimately to the power source. Note that the fuses in the first electrical schematic also apply to the temperature sensor.

Block Diagram:

This diagram details the flow of information and commands that governs the various subsystems of the ROV.



.

Design Rationale:

Overview of Decision Making Process:

Even though the underwater robotics team at Singapore American School consists mostly of new members, many of whom have never had any kind of intensive experience with building robots, everyone's input and judgment is valued in the decision making process.

As the MATE building season got into full swing in the first half of 2013, interested members divided themselves into various groups based on their own judgments of talent. Thus, from the beginning, we were given the responsibility of (and the opportunity to) decide which areas of robotics would suit us best. Furthermore, this system allowed students to explore, grow, and contribute to the decisions made within multiple areas.

For each major decision, our team tries to tap in to the experience of those veteran students who have experience in relevant fields. However, all members present are always able to voice their opinions and informally drive our team in different directions. Generally, members without a thorough understanding of the concepts involved learn the most from such discussions, as different members contribute different perspectives and ideas to the debate. In this way, by the time another debate on a similar issue comes along, these inexperienced members are able to come up with ideas of their own.

Recount Inc.'s decision making process is vital to the success of the team. We have created a cohesive system in which opinions are valued and members are never shut out. This open debate helps us fully develop the rationale behind every design move. Although building each individual component of the robot involves quite a bit of autonomy, the group creates the long term visions to work towards.

We've prioritized teamwork in the construction of this bot by effectively splitting up the work that we have while retaining specified roles in order to better our decision making capabilities. In this way, the best electrical engineers, for example, will focus on the electronics but will also contribute to other subsystems of the robot if need be. Thus teamwork is achieved along with the most effective use of our talented members. Our mentors take a backseat role in the actual construction of the bot, preferring to guide us with helpful hints instead of directing the construction.

Module Design Rationale:

The tether of our robot

The propulsion subsystem was constructed after long periods of deliberation following our time in Hong Kong. Our team learned that we did not have a strong enough system for accurate, quick maneuvers. To solve this problem, we decided to add additional motors for the forward thrusters and the elevator thrusters. Furthermore, we decided that lateral movement was extremely important to accomplish the more complex and intricate tasks (the angular lateral movement that we had during the Hong Kong regional meant that we had to make large macro-movements in order to change our position laterally by a small margin).

Our buoyancy and ballast systems consist of weights attached to the bottom of the ROV as well as compressible floatation devices attached with zip-ties to the top of the bot. This decision was made so that the robot would right itself if placed in odd orientations. The choice to use zip-ties was made because it allows us to easily replace and adjust the floatation devices if need be to adjust buoyancy.

Vehicle Systems:

Recount Inc. is only one year old, and as such almost all of the components we used for this year's MATE competition are brand new. The only modules that we reused from last year's ROV were the two yellow waterproof cameras and a few of the motors. In order to conserve the funds we received from our donor, we decided to recycle these components that could potentially have been very costly for the robot to replace. The systems that accompanied these parts, however, were built entirely from scratch by this year's team (ie. the wiring, the propeller attachment, and the electronics board were all built this year).

New components (designed and built this year) include a handmade underwater camera consisting of a purchased camera that we waterproofed with epoxy into a PVC frame and attached to the ROV. Also, we purchased new motors to increase the total thrust we would have (the black motors are brand new this year). Our decision to spurn bilge pumps in favor of propellers was also made this year, as we realized from experience last year that the bilge pumps weren't effective enough at propulsion for the ROV.

Furthermore, while we may have purchased components in the store, the innovative ways in which we've used them have allowed us to expand beyond the limits of the hardware we could buy with our budget. For example, rather than investing in a complicated and expensive system to guard the motors, we decided to use cheap and widely available fan grills instead that we then were able to cut to shape and use as guards for our propellers.

Payload Carrier Description

At our first design meeting, we examined the different tasks given to us as part of this year's MATE robotics competition. We split up each of the four tasks into different subtasks, and examined the mechanisms that would be needed to complete each of them. Then, by compiling a list of the different mechanisms, we took a look at what features this robot would have to include.

Recognizing the strict 15 minute time limit placed on our team for the competition, we realized that it would be extremely challenging to finish all four tasks. We therefore had to set up a hierarchy of tasks and subtasks that we would complete, in order to focus our efforts during build sessions and practices in the school pool.

Our first tool was a hook, made and bought commercially but positioned on the ROV to ensure compatibility with both cameras and claw. In Hong Kong, Recount Inc. used this simple hook to great effect (we were able to earn 135 points without a claw). In our final ROV design for the international final competition, Recount Inc. is planning on using both a hook and a claw. The hook will be able to lift tools like the temperature sensor and deal with small, precise loops like those on the bulkhead controllers. A camera placed right above the hook will be able to help position the hook for precise maneuvers.

Our claw, complete with silicone for added grip

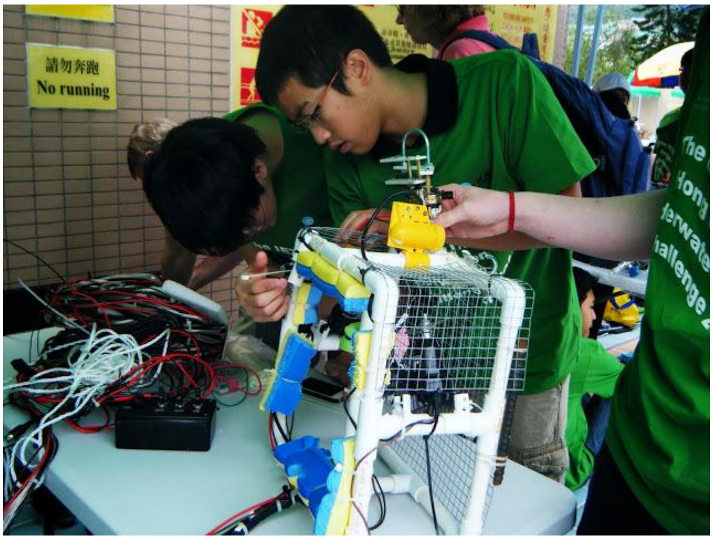
The main tool that we plan on using for the international finals is a claw that we've constructed and attached to the robot. The claw itself was purchased, but the mechanisms we used to control the claw are all home-built. It consists of a black claw that Recount Inc. modified and added silicone to (in order to increase grip). We have a servo and a wire that closes and opens the claw, which we then connected through a tether to the main ROV control bot. This claw will be used for tasks such as lifting the SIA.

Challenges Faced:

<u>Time Management:</u>

In our team, one of our biggest challenges was getting together a group of people who were (and are) extremely involved in multiple activities and multiple robotics competitions. Many of the talented students on the Singapore American School MATE team, were also part of the Singapore American School First Tech Challenge and First Robotics Competition teams, earlier in the year. As such, these members began working on the MATE robot relatively late in the year. Our build season really picked up in the months of March and April because of this issue.

We managed to overcome this difficulty by ensuring that a core group of the MATE team focused on the MATE competition over the course of the early part of the year. We made sure that when we finally had "all hands on deck," we took advantage of the fact and efficiently planned and executed the tasks and testing that we had to accomplish (in a relatively short time). Once we had the larger group of members, we were able to split up jobs into a larger number of groups and complete more components, troubleshoot more parts, and solve more problems faster.



John King working on the ROV in Hong Kong during the regional

Also, since there is no robotics class at the Singapore American School that is devoted to the pursuit of robotics competitions, the members of the Recount Inc. corporation have to put in vast amounts of time after school. Given that the large majority of our team's members are upperclassmen, finding the time to contribute to the robot effectively amidst Advanced Placement tests, final exams, Scholastic Aptitude Tests (SATs), and American College Testing (ACTs) was difficult.

We were able to defeat these obstacles mostly because of the extremely passionate engineers we have on our team. By reducing the high-intensity build season to roughly two months, we were able to draw more students into making the huge time commitment for a relatively limited period. Furthermore, we eventually informally decided to lower the bar of members required to vote for design characteristics that were not absolutely essential to the robot's success and functioning, to basically allow the members who were available for these meetings to take on the responsibility of making these decisions. That way, the leaders who came out to these meetings were able to make the decisions without having to wait indefinitely for members who had other commitments at the time. However, we still made sure to email the group often with developments and lessons learned to ensure that everyone else could follow along.

<u>Gathering Parts:</u>

Living in Singapore, one of our problems was finding cheap, usable tools and materials that we could add to our robot. Many of the parts we required could only be found on-line, and the shipping process to bring such tools over to our school needed funds that we didn't have and couldn't procure in a short amount of time.

Listed below are some of the problems that we came up against:

- The underwater servos that we had were found to glitch when pressure was exerted on them, initially preventing them from being properly used in the claw mechanism (that was meant to hold onto components)
- Finding equivalents to tools and materials that could easily be gathered in the United States or in other cities were often not available in Singapore, as the country does not have as large of a Do-It-Yourself culture
- Initially, we had some problems in trying to use bilge pumps, as we were unsure if our models were going to have enough power to push the robot forward. Ultimately, we decided to go with propellers instead

To solve this problem, we had to realize that there was no easy way around a sound design and advanced planning. Comprehensive design meetings allowed us to pick out tools we needed to ship, and by working with friends and family who were travelling to Singapore from the US, we were able to save on shipping costs that reduced the cost issues dramatically.

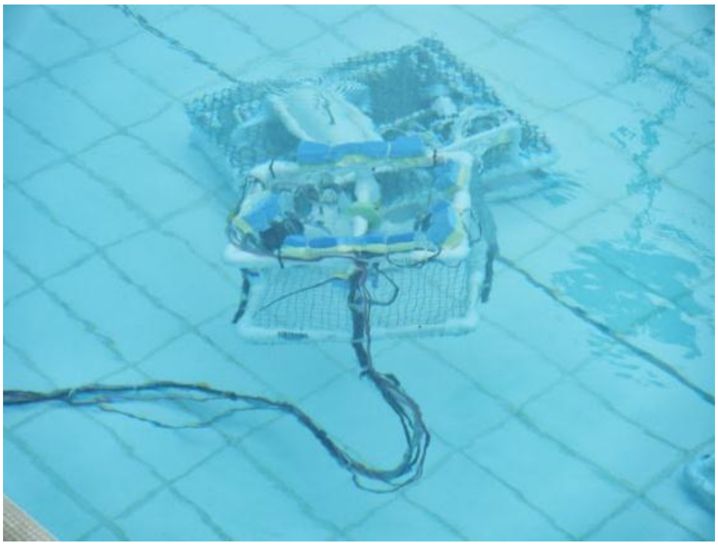
<u>Waterproofing of Parts:</u>

In order to submerge electronics related to the temperature sensor and a third camera underwater, we had to first waterproof these parts using clear drying epoxy. This was challenging because none of our members were adept at using epoxy to waterproof materials, and often our epoxy would be disrupted before it could fully dry. Also, waterproofing exactly the amount necessary (ie. without blocking off temperature sensor readings or making the camera image cloudy) was difficult given the small size of the pieces we had to epoxy.

Our solution to this involved having members learn how to epoxy using spare materials and small amounts of epoxy first. The benefits to this were twofold: not only would the epoxy job for the temperature sensor and the camera now be more precise, but future years of students could benefit from having skilled mentors who could teach them how to epoxy accurately. Also, to limit disruptions we made sure to effectively cordon off the immediate area around the third camera. This was extremely effective, especially when we put notes near the setup explaining that the epoxy could not be disturbed.

<u>Buoyancy:</u>

Another technical problem that we faced had to do with our buoyancy during the Hong Kong regional. Unfortunately, the robot sank below around 1.5 meters underwater, as the intense pressure compressed the floats that we had been using for buoyancy. Before going to the regional, we had not measured the buoyancy of our ROV in deep waters, and this led to a serious problem when our motor was found too weak to raise the ROV from the bottom of the pool.



Our ROV performing in Hong Kong during the regional.

To solve this problem, we first revolutionized our design (see design rationale above) by adding two upward thrusters rather than the one we had before. This will allow us to lift our robot from more than two meters of depth, even with the old floats. We've begun refitting our floatation systems as well, by setting the neutrally buoyant point at around 1.5 meters underwater rather than at surface. This will allow us to become severely negatively buoyant only at really great depths, which we will probably not encounter during our finals.

Lessons Learned/Skills Gained:

One of the biggest problems that we developed was that people had multiple visions of the robot. People would come and do some work. Later someone else would come in and not understand the work done on the robot, and undo it. Although both people had a vision of a good robot, they were building two different robots! Our lead mentor would jokingly call this problem ‘building multiple robots in the same physical space.’ He mentioned that we could solve this problem if we would develop a plan for the robot, and stick to the plan. We changed this later on, and when we created a design for the robot after Hong Kong, we had less problems with people building multiple robots in the same place. We learned how to solve this problem through the help of our mentor, and this lesson will hopefully help us in future competitions.

The Arduino has a rather small resolution for digital voltage measurement: from 0V to 5V, it scales the values from 0 to 1023, giving it a resolution of 4.89mV. The temperature sensor we used is a TMP36 that has a scale factor of 10mV per 8°C, giving the system a temperature resolution of 3.9°C, which is a massive degree of uncertainty. To solve this issue, the temperature sensor code now samples the voltage 250 times, and calculates the standard deviation of the samples to indicate the reliability of the information. As a result, our measurements are much more accurate than those that we took during the regional. We also encased the system in a project box and added a discrete Parallax LCD display to use the temperature sensor without the need of a computer as a monitor.

Lessons from Hong Kong:

In Hong Kong, we learned an incredible amount about ROV's, as we are still a relatively new team. One of the biggest ideas that we learned there was that the simpler a robot was, the better it would perform. For example, our bot was one of the simplest ones there in terms of electrical design, software and mechanical appendages. Recount Inc.'s tool set consisted of just one stationary hook, and our control system was completely analog (as opposed to the digital systems that many other teams used). In the competition, our bot was able to score more points than all of the other teams, showing us that practice is perhaps more important than complex contraptions for the bot. Several of the more complicated ROV's had myriad technical and electrical problems.

Setting up the driver's station in Hong Kong

Troubleshooting:

Troubleshooting techniques:

In terms of our electronics subsystem, some of the techniques that we use to check for problems include resistance checks to find out whether voltage drops are occurring. We use a multi-meter to check the effective resistance and difference in voltage across our tether and across wires underwater, thereby weeding out any faulty wires. Multiple problems, including with a few croc clips of ours, were determined through this technique, which has allowed our electronics to become far more efficient. We also do multiple reviews of our electronics plans; for example, we have a peer review system that allows all of our electronics designs to be vetted by multiple people before they are changed. This is in conjunction with having different electronic engineers on the team check the wiring before other stages of our testing (ie. before power up). Finally, we have many standard bug-proofing techniques: our modular design allows us to test parts bit by bit, and when wiring we always have a check person to ensure that the wiring occurs correctly to prevent any fuse from blowing.

This grill design was tested extensively before use...

We also have multiple troubleshooting techniques for our programs, including using a technology called Github that allows us to post our code online. This has two purposes: it allows us to help other teams who may be struggling with problems in similar programs as ours, as well as allowing us to extend our peer review system to the entire world. All around the world, people can view our program and give us feedback on where our coding may be faulty.

Component testing:

When testing our components, Recount Inc. has made sure to monitor the success of these parts in various conditions, independently and in conjunction with the rest of the ROV's modules. All motors, for example, go through extensive stress testing before being added to the robot. The electronics that correspond to the motors are tested first theoretically (with peer checks of design elements) and then are tested externally before being incorporated to the robot.

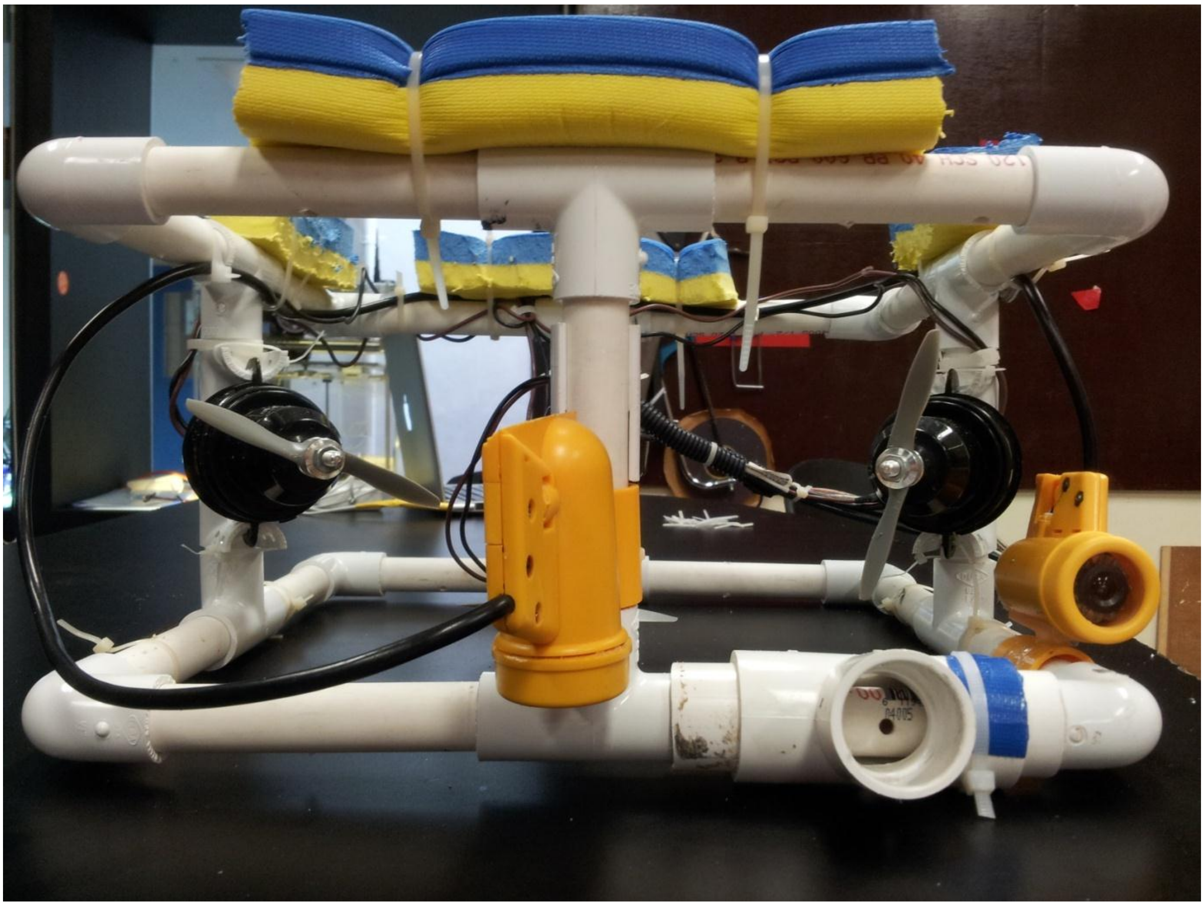
Programs are kept running often for days on end in order to check for any bugs that may occur over the long term. Similarly, small components are tested for hours in a small, water-filled bucket; for example, our claw spent hours in the bucket to check its ability to stay closed for long periods of time. We've found a wide variety of problems this way that could have crippled our bot during the actual competition. Waterproofing leaks, voltage drops, and other electronic issues have taught us a lot about more effective ways to construct these components.

Future Improvements:

New Team:

Although this is the second year that the Singapore American School has sent a team to the MATE competition, the robotics team at our school doesn't have a large exposure among the student body. As such, reaching out to the community will be a huge element of our drive next year. We'll be sure to get the word out about what we're doing and give back to the community that has helped us out.

We will also have to work on fundraising to cover some of the extra tools/parts we may wish to purchase. This year, the fact that the heavy lifting in our build season came so close to competition day prevented us from effectively gathering and utilizing funds beyond those provided by the SAS Foundation at the start of the season. Next year, hopefully we will be able to utilize the lessons we've learned in planning and design to come up with what we need sooner and to raise money for those parts immediately.



Our first ROV, taken to Hong Kong for the regional competition, had fewer motors and a simpler design (with only a hook attached below the middle camera during operation.

New Members:

Also, this year the majority of our members were brand new. Although we do hope to grow as a team for next year by attracting more members (see below), we understand the value of returning members to any team. After this year's competition, we will have gained a wealth of knowledge about robotics that can be put to use constructing a more efficient robot next year. A more accomplished and driven team will result from our participation this year.

However, almost all of the members on the team this year are upperclassmen, meaning that in two years' time a huge portion of the corporation will graduate from our school. While many of us plan to remain involved however possible with the robotics program at SAS, we do understand that many seniors plan to study in the US-- and that the existence of the Pacific Ocean will make direct contact difficult.

To solve this problem, we will begin attracting the freshmen and sophomore classes next year to robotics, getting younger members into the team that we can train. These will be the members who will take over from the older students two years down the road. Hopefully they will develop enough skills over the next two years to train their own groups of students.

Pneumatics:

As of now, we do not have any pneumatic capabilities as a team. However, we do plan to purchase and practice using pneumatics on our robot, as we understand the potential uses of such tools on robots in the future. Given sufficient practice and preparation in the "off seasons", we will be able to effectively implement these kinds of technologies for our robot, and develop our team's capabilities in the process.

Similarly, we understand that over the years, our collection of materials and experience will only continue to expand. We will continue to learn more about building robots and collect more motors, propellers, PVC pipes, fittings, etc. as well, year after year. Our eventual goal is to win first place in the Hong Kong regional and go on to the worldwide competition.

Control System and Monitors:

Next year, we would like to use a digital control system. Our current system is fine for the most part, but it would be an easier robot to drive if instead of a switch box we used a joystick or two with PWM motor controllers. Furthermore, the CRT monitors we're using this year are extremely difficult to use. For one, the dimness of the monitor can make it hard to navigate. If we used an LCD display instead, it would make driving easier. All these changes would be beneficial, and are things that as a team we would like to add.

Reflections:

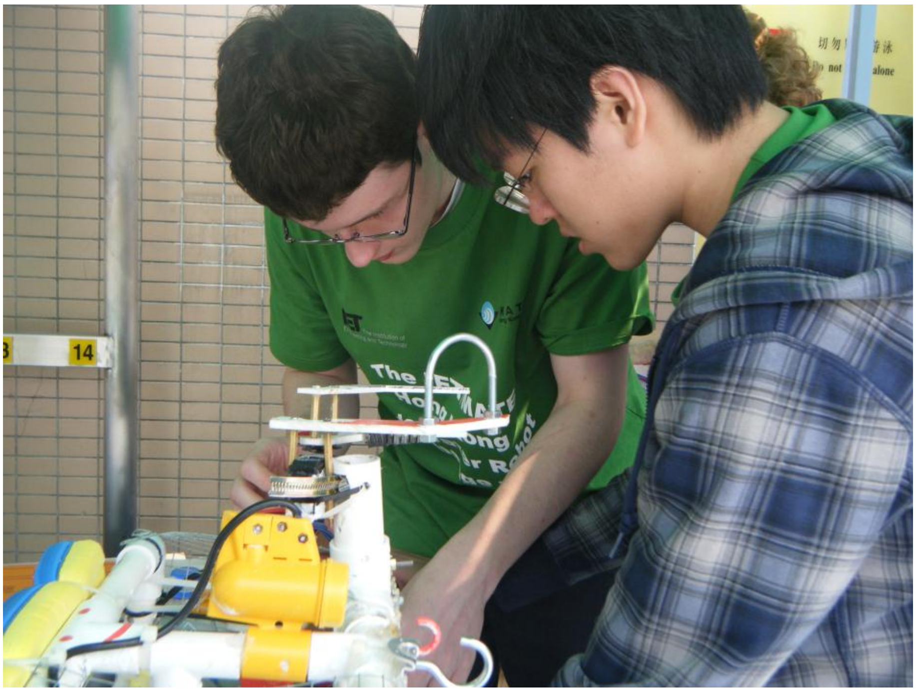
Team Reflection:

The members of the Recount Inc. team have had an incredible experience building the Orchid II. Constructing the robot has required skills that were, six months ago, far beyond our imaginings. We have developed so much individually and as team, and collectively we have learned so much about robotics, teamwork, and effort. Our hard work has paid off at the Hong Kong regional, and hopefully we perform well at worlds as well!

Member Reflections:

The MATE 2013 build season was quite possibly one of the most enriching experiences of my life. Previous to this encounter, I'd only known one or two of the members of my team, while my other teammates were mere faces in the crowd that I sometimes passed by in the hallway. Participating in this building our underwater bot allowed me to deepen my relationships with every single member of my team. Challenges were shared and successes were embraced. As we proceeded through compiling materials to enhance our robot, we met our single biggest technical obstacle. In order to complete all four tasks, a handling arm was necessary, a tool which required manoeuvrability as well as conformity with required regulations. In the end, after many suggestions and much discussion, we forsook the intricate yet delicate servo turned claw for a simple hook. By taking this leap of faith, we entrusted our pilot with the task we were having the most trouble with before, which was to deploy the temperature sensor. Our pilot, whom we all call 'king' due to his masterful driving skills and his last name, pulled through, allowing us to obtain data on the temperature within four degrees of accuracy. This was just one of the few experiences where we operated as a team to defeat obstacles. I eagerly await next year's challenge.

-Jack Lin, Chief Operating Officer



Jack Lin and Will Whalen-Bridge jointly examining the prototype ROV claw design in Hong Kong

In that past all of our robots have been built first then designed later. We always intended to design and then build, but in the excitement of the challenge and the rush of the competition, we would always start building before we even knew what we were doing. This would cause us problems later down the line, as we never quite had a design and either people would build two robots in the same space, or we would encounter problems that we did not predict later down the line. We did this with the first version of the ROV, but after our regional in Hong Kong, I decided that we should redesign the ROV before we rebuild it. I worked to learn how to use software like Autodesk Inventor, so that I could design the robot with a high level of precision. By learning to use CAD software , I not only learned about the design process, and how to use difficult programs, but I also created a robot that required fewer repairs after it was built.

-Shane Rozen-Levy, Mechanical Engineer

References:

Bahr, Frank. "Acoustic Doppler Current Profiler (ADCP)." *WHOI : Instruments :*. N.p., n.d. Web. 06 Mar. 2013.

Getty, Brandon. "How to Waterproof Electrical Cable." *EHow.com*. N.p., n.d. Web. 10 Mar. 2013. <http://www.ehow.com/how_7434869_waterproof-electrical-cable.html>.

Koppenhaver, Nate. "ROV (underwater) Temperature Sensor Design Considerations." *Electrical Engineering*. Stack Exchange, 14 Mar. 2012. Web. 06 Mar. 2013. <http://electronics.stackexchange.com/questions/28060/rov-underwater-temperature-sensor-design-considerations>.

Moore, Steven W. *Underwater Robotics: Science, Design & Fabrication*. Monterey, CA: Marine Advanced Technology Education (MATE) Center, 2010. Print.

"Underwater ROV." *Instructables.com*. Autodesk, n.d. Web. 06 Mar. 2013. <http://www.instructables.com/id/Underwater-ROV/>.

Acknowledgements:

Recount Inc. would like to sincerely thank the SAS Foundation for the funding we needed to carry out this robotics project. Our team would not have been able to function without the generous funding allocated to us.

We would also like to thank the MATE center and the Hong Kong regional organizers and its sponsors for giving us the opportunity to participate in a world class robotics competition. We also really look forward to taking part in the international competition and are grateful of the learning experience it has been thus far.

Finally, we'd like to thank Mr. Millar and Mrs. White for helping with the design and construction of our robot. Without their support, our robotics team would not have been able to function.

The Recount Inc. team in Hong Kong!

APPENDIX 1:

One Degree North Pre-Deployment Safety Checklist

Electronics:

- Check male connectors for defects or debris.
    - Power distribution box
    - Control box power cable first terminal
    - Control box power cable second terminal
    - Temperature sensor power cable banana terminal
    - Temperature sensor power cable dual port adapter
- Check female connectors for defects or debris.
    - Power distribution board unfused ports
    - Power distribution board fused ports
    - Control box input
    - Temperature sensor input
- Check switches for proper spring-back
- Check control box-tether wire connector interface
    - Gentle-pull test interface for bad connections
- Examine tether for defects or loose wires
- Examine wire splice joint
    - Deck side
    - ROV side

Propulsion:

- Check propeller clearance
    - Left propulsion, clearance with metal motor guards
    - Right propulsion, clearance with metal motor guards
    - Elevator motors, clearance with bottom motor guards
    - Lateral propulsion, clearance with structure support and motor

Claw:

- Check wires
- Check spring
- Check spool screw
- Check connector string

Entanglement:

- Tether with propulsion
- Claw wire with propulsion

Fuse:

- Main fuse
- 3A fuse (leading to temperature sensor)

APPENDIX 2:

ROV Orchid II

Operation Manual

Recount Inc.

Singapore American School

Introduction:

The Recount Inc. ROV Orchid II is designed to complete a primary node and install a scientific instrument on the seafloor, install a temperature sensor on an underwater thermal vent, replace an ADCP, and to remove biofouling from instruments. The ROV weighs 5.3 kg. It has a hook and a claw to perform these tasks. The robot can move vertically, laterally, rotationally, and forward and backward.

Deployment:

1. Ensure tether is untangled.
2. Ensure safety line is attached.
3. Confirm that all propellers are clear of obstructions.
4. Plug control box into PD board, make sure that it is red to red and black to black.
5. Plug the T.V.s into the cameras.
6. Plug the T.V.s into the voltage source.
7. Plug the cameras into the voltage source.
8. Check to make sure that you are getting a clear image through all three cameras.
9. Plug in temperature sensor to PD board.
10. Confirm all switches are in neutral position or off.
11. Plug in PD board to voltage source.
12. Enable master switch.
13. Enable control box switch.
14. Test the propulsion.
15. Place the robot into the pool.
16. Shake robot to remove excess air bubbles from the frame.

Modifications:

If the ROV's buoyancy is off, the floats or the ballasts can be altered to ensure neutral buoyancy. Another alteration to the robot that can be made is to change the payload carrying systems. The hook can be removed and replaced with the other payload carriers like a screw eye or an rod. The claw can also be easily removed if the ROV's height must be reduced.

Trouble Shooting:

If nothing seems to work first check to make sure that everything is plugged in correctly as described in the set-up section. If that does not fix the problem some additional troubleshooting steps include:

- Checking the fuses
- Ensuring that the propellers are not obstructed or tangled

Known Issues:

- The servo for that runs the claw occasionally fails.

- The buoyancy has fluctuations based on depth. At depths of 2 meters and above, the robot may be negatively buoyant, and at depths above 0.5 meters it will act positively buoyant.

APPENDIX 3:

Underwater Temperature Probe

Operational Manual

Recount Inc.

Singapore American School

Introduction

The Recount Inc. temperature probe is designed to measure the temperature of water flowing out of an underwater vent. The user interface of the probe, the receiver, consists of a reset button, an LCD display and a piezoelectric speaker. The operational interface of the probe consists of a TMP36 digital thermometer mounted on a conical adapter to fit over the vent and hooks at the top. The probe has weights at the bottom and floats at the top, to ensure stability. The weight underwater is about 6gf (0.059 N). The interface and probe is connected by a gray tether with a three-prong connector.

Deployment

1. Ensure tether is untangled.
2. Extend tether plug from receiver to shore, and extend the tether of probe side to 1 meter.
3. Attach temperature probe to ROV.
4. Plug tether jack to receiver, taking care of polarity. The black side shall face outwards of the device. Refer to the arrow on the devise itself.
5. Connect power to receiver.
6. The splash screen will display for 2 seconds and disappear.
7. When ready to record, press the reset button, at which point the device will reset and reset time to t=0.
8. The screen will light up as soon as new data gets collected, and a beep will sound. The data will be shown on-screen as long as there are no new data.

Visual Information

The screen displays the following information in the first row: the time in seconds since the first measurement of the currently displayed measurement.

The screen displays the following information in the second row: the reported temperature, in Celsius; the standard deviation of collected and averaged samples. A standard deviation of less than 0.40 is acceptable.

Modifications

Users may modify, before mission, several constants:

- Calibration
  - To calibrate, please change the float value calibration to a desired amount. For instance, if the temperature is consistently 2 degrees above normal, change the value to -2.
- Sampling delay and Sample size
  - To ensure high accuracy, the default behavior of the probe is to measure the temperature 250 times as defined by the variable samples, then average the value to display.
  - The default delay between individual samples to average is 1 millisecond as defined by the variable (sampleDelay). Users may change these values as they wish. Note that increasing sample delay may delay the display of results.
- Measurement Interval
  - The MATE mission requires teams to record values every 90 seconds. However, if users wish, the interval may be changed to an arbitrary amount as defined by the variable interval.

Accuracy

The probe, when properly calibrated and underwater, will consistently report the temperature within two degrees Celsius.

The standard deviation display is a rough indication of accuracy of data. Generally, a standard deviation value of less than 0.4 is within normal circumstances. If too high, please read the troubleshooting section.

Troubleshooting

For any problem, try disconnecting and reconnecting power to the receiver. If this does not solve the problem, ensure that:

- The tether is correctly plugged in.
- The reset button is not pressed.
- The tether underwater is free of damages.

Known Issues

- When the device is connected backwards, the temperature sensor may heat up and be damaged.
- When device is not connected properly, standard deviation numbers may sometimes overflow to the first space of the LCD display.