



VALOR MARATIME INTERNATIONAL

Technical Documentation

Team Members:

Amber Wootan (CEO)

Meaghan Giard (CFO)

Bret Corrigan (Chief Engineering Officer)

Chloe McConnell (Chief Marketing Officer)

Mekiah Smith (Chief Technical Officer)

Jacob Suarez (Pilot, Chief Pneumatics Engineer)

Holly Neill (Mentor)



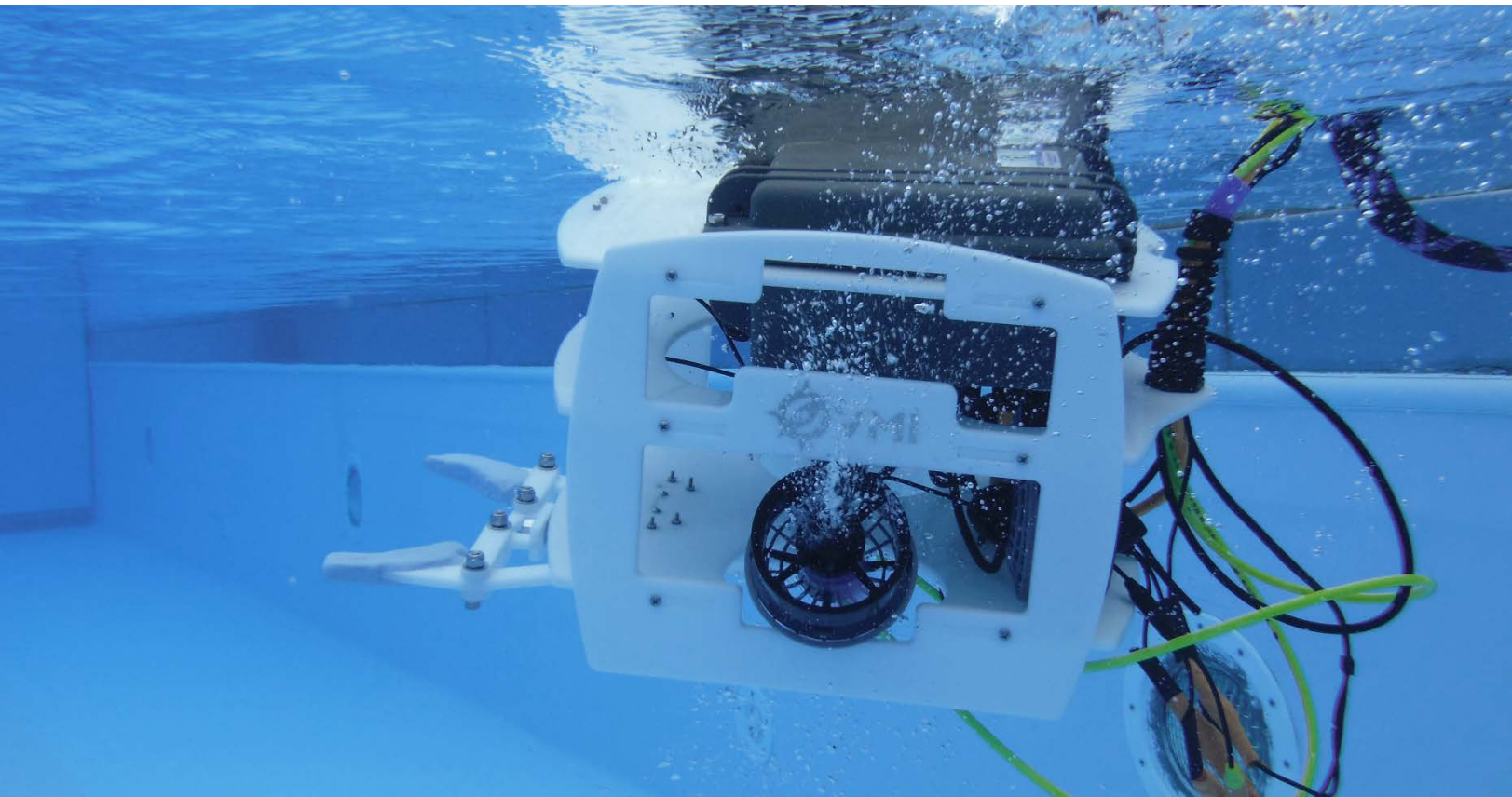
Valor Christian School International
Beaverton Oregon

Table of Contents

Contents

Table of Contents	1
Abstract	2
Teamwork	3
Design Rationale	5
SID	15
Safety	16
Critical Analysis.....	17
Future Improvements	20
Accounting.....	20
Acknowledgements.....	22

Appendix-Budget and Project Costing



Abstract

Valor Maritime International is the newest addition to the Valor Christian School International Robotics team. Our company will be competing in the Ranger category for the first time. Galia is our flagship remotely operated vehicle (ROV), which is designed to complete tasks related to the theme of Jet city: Airplanes, Earthquakes, and Energy. These tasks include installing and recovering “crashed airplanes”, “water turbines”, and a “seismometer”. As a team we have used our strengths to make Galia capable of achieving each of the mentioned tasks. Our team is made up of both experienced and new members, ranging from high school freshmen to juniors. We are all from Aloha, Oregon. Each person adds a unique perspective to the design of our ROV. Without each of our perspectives, our ROV would not have come together. We are excited to be the newest members of Valor Christian School International Robotics Team.

Teamwork

Company Effort:

Valor Maritime International is made up of three juniors and two freshmen who have worked tirelessly to make an effective and successful ROV. Amber Wootan, our CEO, sets up meeting times, and communicates with team members about upcoming events. Amber also is quick to lend a hand with tasks like paperwork or building the ROV. Meaghan Giard, our CFO (Chief Financial Officer), works tirelessly to making sure our project is financed within the budget. She also works on the documentation and helps with the ROV. Chloe McConnell, our CMO (Chief Marketing Officer), handles our company's website and Facebook page. She also helped plan our outreach and made sure that the fourth graders had a blast during our collaborative activity. Mekiah Smith, our CTO (Chief Technical Officer), has been a Godsend. He has designed the brains of the ROV and has programmed the ROV to accomplish the required tasks and move around. Bret Corrigan, our head engineer, lead the design of our ROV's body, using Computer Aided Design (CAD) tools. He built a large portion of the ROV after it was printed. Jacob Suarez has served as our CPE (Chief Pneumatics Engineer). Jacob was a big help with building and designing the ROV. He also contributed in making the props for the competition. Our team has worked together for countless hours on making this ROV work. Each person used their strengths and made our company what it is today.



Figure 1 Our team at Regionals Listed from left to right: Meaghan Giard (CFO), Mekiah Smith (CTO), Amber Wootan (CEO), Bret Corrigan (Head Engineer), Chloe McConnell (CMO), Jacob Suarez (CPO & Pilot)

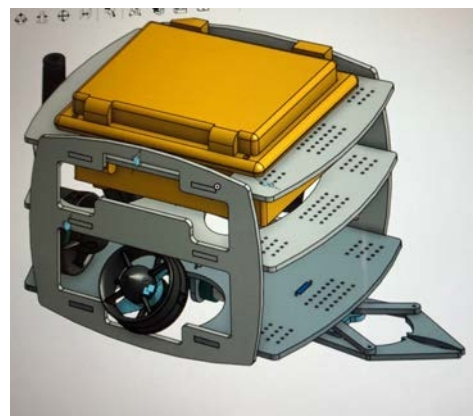


Figure 2 3D rendering of Galia, using the CAD

Project Management:

At the beginning of the year, we sat down and made a list of what needed to be accomplished for us to be a well-organized team. Meaghan (our CFO and Program Director) set deadlines for us to meet. Our schedule is included below:

Engineering Timeline

December 20, 2017:

- Basic Brainstorm of CAD Design
- Basic Understanding of Programs
- Supplies List Done

January 26, 2018:

- Model of CAD Design Done
- Motors Programmed
- All Supplies Orders

February 23, 2018:

- Start assembly of the ROV
- Demonstrate control system for Motors with joystick controls
- Begin Coding the Rest of control system
- All Supplies received

March 16, 2018:

- Testing control program
- Finalize Video System

April 6, 2018:

- Finish ROV assembly
- Finalize control system software
- Begin Practicing with the ROV

April 20, 2018:

- Operational ROV Ready for Competition

Marketing & Documentation Deadlines

December 20, 2017:

- General Brainstorm of company identity

January 26, 2018:

- Develop company identity materials
- Finalize logo

February 23, 2018:

- Begin work on marketing display and company documentation

March 16, 2018:

- Outline of marketing display and company documentation finalized

April 6, 2018:

- Have all Badge and T-shirts.
- Presentation assignments Done

April 20, 2018:

- Marketing display and company documentation complete

These deadlines have been a great way to stay organized and focus throughout the duration of the competition. We organized the deadlines into different sections based on the MATE competition. Each person also had their own set of deadlines that they set for themselves. Our CFO worked on finances and ensured funds were raised and supplies budgeted properly. The CTO oversaw programming the ROV and our Chief Engineer met deadlines that were in line with building the ROV. The deadlines involving the website and blog was completed by our Chief Marketing Officer, Chloe McConnell. The dates and tasks were organized in correspondence with each other so that everything would be completed in before the competition. As with any project, big or small, problems occurred that affected these deadlines. When problems arose, the team followed protocols that were set in place. The first step was to consult the CEO, Amber, for her opinion on the situation. If a solution couldn't be easily resolved, we went to our advisors for

advice. This happened several times, but our team adapted and overcame every obstacle. This is exactly what made us who we are as a team, and through it all we became even more tight-knit.

Our team consisted of many different personalities and skills making us unique. At the beginning of the year we sat down and discussed our strengths, and to what position each person should be assigned. We elected Amber Wootan as our CEO because she had the most experience. Her role as CEO was to provide us direction and support us in all we do. Then we needed to elect a CFO and we chose to elect Meaghan Guard since she is skilled in math and finances. Chloe McConnell, our chief marketing director, was elected because she wants to go to into marketing in college. This job has given her a chance to grow as she prepares for college. When it came to the technical side we elected Bret Corrigan as our chief engineer since he had previous experience with using CAD software to build a ROV. Our CTO was Mekiah Smith, who was elected because he was on MATE last year and is very interested in programming our ROV. He has been amazing at what he does and has handled this task very well. Lastly, Jacob Suarez is our chief pneumatics engineer and was the newest member of our team. Jacob filled the last spot and proved to add strength to the team in many ways. Each one of the roles were carefully considered and have proven to be the right ones. These people truly make up a remarkable team, and we have each grown in many ways.

Design Rationale

Preface Process

When Valor Maritime International designed Galia the ROV, the head engineer, Bret Corrigan, and CEO, Amber Wootan, modeled how Galia would look. Before she was modeled, the team had decided that the ROV would use Blue Robotics T100 motors. Using the specifications for the motors, props were cut out of old wipe containers. Using these motor props and foam boards, the head engineer and the CEO created a model of Galia. This model helped define the size specifications, the motor placement, and the brain. We first looked at the circular size for bonus points and decided to meet that size requirement. We then determined that we wanted to find the right size to fit but we had to find a box first. We found the box and measured the size so we could make all the parts to fit. We then confirmed that we could make this, so we did several test drives, changing height, width, and length each time. We originally didn't design our ROV to have a third tier. We thought we had figured out the size we wanted to run with, but then we had to find the motor placement. It took us a little bit to engineer the motor placement so that it would work. We figured out where they would go with a four motor design and then we designed the claw design for the ROV. We looked at our other team's claw design but we determined that the "down-claw" design was not what we wanted, and so we turned to the internet for inspiration. We researched for a long time to make sure we would have a claw design

that would suit us. We then determined that the front facing horizontal claw would work best so we could sit on the ground and grab whatever was needed in each task. After finishing all of our preface modeling we started our digital design using Onshape.



Figure 3 The mock motor pieces for modeling our robot

Frame

Using all of the specifications from our preface modeling process, we started on our ROV. Bret Corrigan worked with the CAD program so we could design our ROV in 3D for our sponsor, Micron Laser, to cut it. We first designed our bottom piece, for which we made sure all of the specifications we laid out before were put in. Then we made our side piece with the specifications we picked before, plus a few screw holes so we could screw together our ROV parts. Then it was on to our biggest task, which designing the top. We used the bottom piece because it already had our specifications. Then we measured the box's width and length. Then we measured all the grooves and eventually made a design of the whole box and made sure all of the grooves were in the top of our ROV so it would fit just right. The next step after the top was done was to

figure out the motor placement. After deciding where the motors would be, we made the screw holes and the adapter for the motors to have the desired angle. We added the screw holes on the back of the ROV's bottom part. Our motors were facing out of our ROV so that we could go forward and backward. The adapter was made out of filament which worked when first tested it, but in the end, it did not function how we liked it so we scrapped the idea. Learning from that idea, we need to know what we could do to make it better, so we hit the books. We were looking for new designs, so we bounce ideas off of each other and finally figured out our design, which worked stupendously. After having all our basics down then we got to specifics. We realized that the angle motors we wanted were not doing to fit with just a slab so we had to make holes in the side, so our motors would fit properly. Then we realized that no water would be able to flow through the motors, so we made a hole in the bottom on both sides, so we could have water circulation. Since all the motors got worked out and fit perfectly we decided that we wanted our logo on the side, and we changed the side piece design to showcase it. Then we needed to have mounting holes for all of our cameras, so we made many holes across our ROV. We also made a third tier primarily for mounting, which was not in our original design ideas. Our last step in the ROV process was getting a better way to connect all of the pieces. After some research we found that tab connectors would be our best option and so we ran with it. At this point we had finished our whole ROV but then we knew we forgot something. It was the claw.

The Claw

The claw was, and is, the most complex part of our design. The whole team was looking at



Figure 4 Our team working on our claw

both previous winners and also claw designs on the internet. We came up with our best ideas and held a team meeting. In that team meeting we were each advocating for our ideas and we voted in order to choose our winner which was a front facing horizontal claw. From there on it was our mission to find ways of working with this claw. We had ideas of syringes and pneumatics and several other devices, but we finally chose pneumatics because we thought it would hold the power to close our claw and hold on to things better. Since the people on our team last year had a bad experience with syringes at the competition, we knew we had to step it up. The final step before we could design the claw was finding a way using pneumatics that when the ROV went forward the claw would open. Late nights and early mornings were spent trying to figure out what to do with this claw.

Then we thought piece by piece and finally

figured it out. The first piece Bret Corrigan made was a piece to connect to the pneumatics because we knew that it was needed. Then we connected that piece to another piece which had holes so we could later attach even more connecting parts to it. Then we came up with a universal connection part that we used to attach each piece. Then it was time to make the grip. We had to make it long and skinny, so we made the back part especially narrow, so it could easily connect to all of the previously designed parts. We then added two screw holes, so we could connect it with the ROV and the pneumatics. The grip is made with a rounded inside so that we could pick up PVC pipes in the competition. Then we needed to make pieces to connect the claw to the ROV so we can extend the claw further. Finally, the entire claw was connected to the ROV and pneumatics. We fitted it all to the pneumatics and made tabs to connect them. After the finishing touches of rounding all of the edges and making sure everything fit, we had finished our claw. Finally, all of the ROV was completed after four months of tireless work.



Figure 5 Blue Robotics T100 Thruster

The Motors

After much contemplation, we chose the T-100 thrusters because they were less power than the T-200 motors, which have too much power. The T-100 generates plenty of power with 23.13 Newtons of thrust in the forward direction and 18.13 Newtons of thrust in the reverse direction, which would give us just enough power so that we could control our ROV well and still try and complete all the tasks in fifteen minutes. The T-100 thrusters are also more cost efficient.

The ROV we made this year was a four motor design. We used four motors because it was our first time competing in this competition.

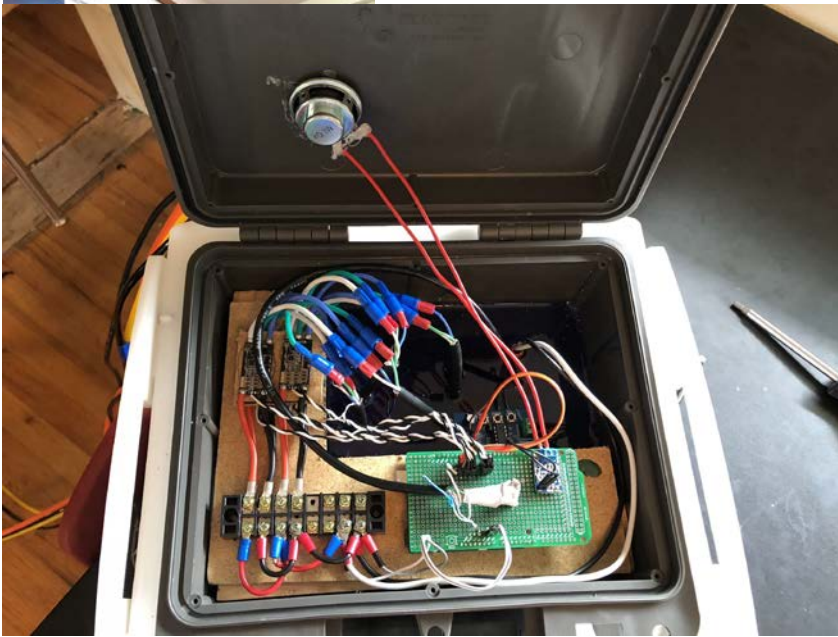
Since it was our first time we did not have any base code or any idea of what a six motor design looks like. In this four motor design we chose to have two in the back for our basic forward and backward motions. We decided to make our motors have a shallow angle. We made this angle so that we could strafe. Strafing is slightly moving side to side while not fully turning. Then we could also go up to so they could be multi-purpose motors. Our final step in the motor design was the prop guard. The robots motors are very dangerous and after inspection, we decided that if the divers would be so kind as to dive for us than we should be very kind and be safe and add prop guards so they don't chop off their fingers in the pool.

Cameras

This year our team decided we would have two cameras on our ROV. We used two analog backup car cameras. These cameras are small and cost efficient. They are all pre-waterproofed, but just to be safe we made sure to waterproof every little corner to make sure that it would not fail. We bought a lot of extra cameras just in case of emergency too, which came in handy because our cameras broke at the regional competition and we had to redo them one the day of the competition.

The Seahorse Box

When we started our competition season we determined we had a few preliminary matters to deal with. One of them was our underwater box. We decided to go with the Seahorse Box because it was cheaper than a hydrotube but also gave a lot of room to work with. The box was pre-waterproofed and was proven to work so we decided it was the safe and clean option for our ROV. Then we drilled holes for our strain relief so we could have wires coming through to our hardware inside. We also poured epoxy inside so that the holes we drilled would be waterproof. We tested this several times in the pool and it all went smoothly.



Tether

Our tether consists of 3 main parts: our video wires, our pneumatic tubes, and our power cables. We had four cameras so our video wire consists of the four camera wires and also the cat 5 connector for the Arduino. We had one main power cable. We used an extension cord cable and cut of both the ends so that we could crimp multiple plugs to connect easily to our control box. We also had

the three air tubes. The three air tubes were for the pneumatics and also for a task. Two of the three were for the pneumatics for our claw. We connected it to the Pneumatics on the ROV and connected it to the solenoid valve and then to the air compressor. The last one was the the airbag task, which required us to fill it up and bring it to the surface so it was connected to the

other solenoid valve in our control box. It all gets put into a seven blade trailer connector to fully connect to the poolside electronics.

Onboard Electronics

Onboard our roV contains one arduino uno and four electronic speed controllers (ESCs) as well



as a power strip for us to better organize the distribution of power. Keeping these parts onboard the roV helps minimize tether size and also makes less things we need to put in the control box. All of the components onboard our ROV are fastened to a piece of plywood located inside the box onboard our ROV. This piece of plywood is elevated to the top of the box so that if water manages to get inside the box it would not be fatal. But that is very unlikely to happen. We insulated all of our wires connected from the roV to the tether in epoxy to ensure no water will get inside. Using ESCs is much better than last years design because it lets us to control the speed or our ROV rather than just have go a static speed, letting our ROV do more precise maneuvers. Attached to our power strip we have our 12 volts and ground wires that power our arduino uno, and four ESCs. Mounted on top of our arduino is a breadboard which we have the input and output wires attached to for comunicacion with our control box on the surface. The bread board also attaches also attaches to the analog pins on our arduino to the motors so that when the arduino reads the signals from our control box it can decipher it and tell the motors to turn on or off. We also have our absolute orientation sensor (AOS) which can tell us the orientation of our ROV on 6 axis and display the information accordingly on our computer screen. To have our arduino onboard the ROV communicate with the control box we use a wire called cat5 containing wires for RX(receive) TX(transmit) ground and 5 volt.

Control Box

Our control box consists of fourteen parts and one monitor. One of the fourteen parts of the control box is the relay module. The relay module is a switch that allows two other of our parts which are the solenoid valves to let air pass through. That are wired through our air compressor. The pneumatics use the air and also our air tube for the lift bag. There is also four cameras that are all connected to both the tether and the video splitter plus our one monitor. There is also a one hundred and ten volt power plug that connects the power to the video splitter and also the monitor. There is also a Arduino UNO R3 which is like a mini computer for the whole control box which controls the motors and transmits info to our robot's brain seahorse box. We have both arduino cords for the one in our box and also the one on our ROV which will ultimately be plugged into the computer for our code to be processed by the arduinos. We also have a power filter which all of our video wires go through so that they all can get as much power as needed. The biggest part is the power distribution fuse block. The power distribution fuse block gets power through a DC power supply through a 25 amp fuse which then distributes the power into three major categories of our control box the camera, pneumatics, and propulsion systems. The camera system gains power through the power distribution blocks 3 amp fuse and then runs through all of the camera system. The pneumatics also get power through a different 3 amp fuse in the power distribution block and then to all of the pneumatics system. The final category is the propulsion system. The power that goes to the propulsion system is through a 25 amp fuse that runs through the power distribution fuse block which then gets put into a seven blade trailer plug which will in turn get plugged into our tether to go to all of the motors and the whole propulsion system.

Code

The ROV, as well as our team's computer (attached to our control box), was coded in the programming languages C++ and python 2. Now we have a total of 2 arduinos (both are arduino unos) one is inside the control box. This one's for controlling the claw, and the other one is onboard the ROV for controlling the motors. Both of the arduinos were coded in C++ while it was the computer that is attached to our control box that is running the python program the displays all of our technical diagnostics, such as our ROV's orientation, what buttons on our controller are being pressed, whether our claw is opening or closing, etc. The purpose of the python is to use serial communication to read the controller and send instructions to the ROV for its onboard arduino to interpret and set the motors accordingly. We even coded python modules for binding controls to specific motors that we can use in future mate competitions. But sending signals to the arduino through serial communication means that we can only send one byte at a time to our arduino (the rate at which it sends compensates for this.). Because of this our python had to form packages to send to our arduino. Now this may seem easy but it was quite the daunting task. So our controller is analog and so our motors, so we want to be able to control how fast our motor go depending on how far we push the joysticks on our controllers. So our

solution to this problem was to use many different bytes, each meaning different speeds. 'A' being full reverse 'U' being stationary, and 'K' being full forward and all the characters in between are different speeds in alphabetical order. We did something similar for the arduino controlling the claw except it did not need to be analog so 1 is on and 0 is off. As for our programs display window we used a non commercial python module called 'pygame' to help as for it has support for reading our controller and for creating a window we can display information in. We would say that the most enjoyable part of the coding was experimenting with the motors!

Buoyancy and Ballast

In order to achieve neutral buoyancy we needed to know how much water was being displaced by our bot and add weight accordingly to reach equilibrium. We first calculated the volume of our seahorse box and then we estimated the volume of the structural framework. After we added these two figures together we converted the sum into kg. We calculated that 8.62kg of water would be displaced but since our bot only weighed 6.8kg we had to add 1.82kg of weight to it.

$$\begin{aligned}20\text{cm} \times 25\text{cm} \times 10\text{cm} &= 5000\text{cm}^3 \\29\text{cm} \times 29\text{cm} \times 32\text{cm} \times 10\% &= 3619\text{cm}^3 \\5000\text{cm}^3 + 3619\text{cm}^3 &= 8619\text{cm}^3 \\b &= 8.62\text{kg} - 6.8\text{kg} \\b &= 1.82\text{kg}\end{aligned}$$

Control Systems

For controlling our ROV we used a usb game controller. We chose this because it would be the easiest and most efficient way of having a computer read the controller and allow us to control the speed in which the ROV moves at. And the controller works well with the module we used for displaying our ROVs diagnostics (see the coding section). As for binding what controls on the game controller made which motors turn on and off we wrote a code library that made it super easy to tinker with the way the ROV rather than the way we used to have it set up where we would have to re do alot of our code if we ever had to change anything. As for the optical component of controlling our ROV we have two cameras mounted on the front of our Rov one that points angled toward the claw allowing us to see what we are picking up and another pointed straight forward so that we can see where we are going. Both of these cameras display their output to the big monitor mounted flush to the face of our control box.

Finishing Touches

Once we finished the ROV we had to do a few things. Firstly we had to sand down all of our connectors because they were a little too big for the holes. Secondly we had to cut part of the claw design that connected the claw to the ROV because of the air ports in the pneumatics. Then we had to make proto-putty for our claw so that we could grip better. We also lost a drill bit in our ROV because it broke inside. An addition we made was also epoxy in our logo and also in our box.



Figure 6 The Epoxy over the VMI Logo

Overall the ROV was an incredible experience and we have been having so much fun with it!

Understanding

This year's ROV competition encompasses many different aspects, including having a ROV that can help with the installation of water turbines off the coast of Washington. The understanding of power produced by water turbines off the Washington coast will help with helping providing energy for developing countries such as Haiti, who are still devastated from the earthquake that happened in 2010. Another aspect of this year's competition are the earthquakes. The earthquake section focuses on data collected from OBS, to understand and predict upcoming earthquakes. This data collected can greatly help nearby areas by giving advanced warning of disastrous earthquakes.

With these tasks in mind, we designed Galia with the highest priority of her completing the tasks with ease. She was designed with room for the motors to be housed safely, and a pneumatic claw was positioned at the bottom. This allows for items can be grabbed within the

camera's field of view. The Galia wouldn't have to be turn to the side, or have to backup to retrieve the object. The decision to use pneumatic over hydraulic was based upon the success with a previous team last year. The motors are positioned at the back of the ROV, to propel it forward, and at the sides to provide steering and propulsion up. The motors were positioned for the least amount of force to be exerted to accomplish tasks. We also wanted to limit the power needed for the motors to allow for more systems to be integrated, including the backup cameras and Arduino-operated pneumatic claw.



Figure 7 Our fabulous claw created by Bret Corrigan on CAD. The claw uses pneumatics to open and close the claw.

Build vs. Buy

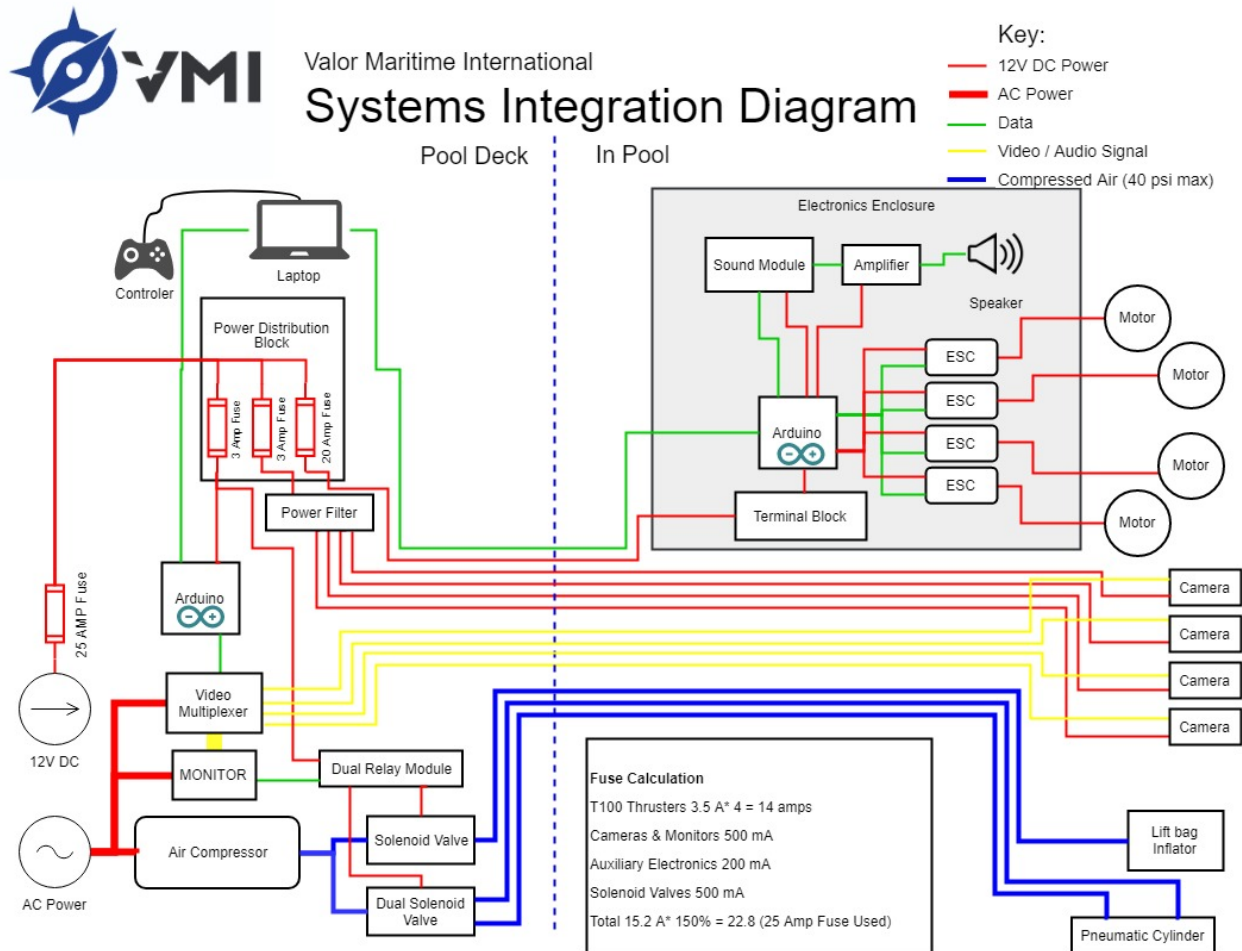
As a team we chose to build our ROV using commercially bought products. There was an option that we could home-build our products. This option did not seem as beneficial to our ROV and overall budget. Home-building is a much riskier business and can cost more due to having to rebuy supplies if things break because they were not built right. That is why our team came to the conclusion that it would be beneficial to buy supplies through Blue robotics and other hardware stores. Commercially buying our supplies can almost guarantee that they will last longer than those that are home built. This is because they are more reliable built by professionals rather than someone who is just learning. Another factor in buying commercial products is the hope of using components in competitions for years to come. That is why our group chose to buy commercial supplies over home-building everything.

New vs. Used

Our team is newly formed and is brand new to the ranger class therefore we needed to buy new supplies. As a brand new team it is very difficult to re-use supplies and therefore we purchased or had supplies donated from a number of places. For instance, our brand-new delrin was donated and cut to our exact specifications. Also, our motors were purchased through Blue

Robotics. In buying new products we hope that our ROV will last longer and be able to be used more than just this competition. Having this kind of reliability is beneficial since we were spending money on building this ROV. As we were building the ROV we were fortunate to find tubes from prior projects in our science department. We examined this tubing and saw that we could use these for our ROV. Therefore the tubing we used from older supplies for our ROV. This was more efficient and helped us spend money on other more expensive supplies. These methods truly have made our ROV what it is. It has been very beneficial to our brand new team to buy new products for critical components, while also using found supplies.

SID



Company Philosophy and Safety Features

Safety is one of our team's top priorities. We went above and beyond to ensure that every aspect of our ROV development was done safely and securely from the moment we began designing to competition day. During the design and production process our team looked out for every possible safety hazard to ensure that our ROV was abiding to the 2018 Mate ROV competition safety guidelines.

Physical safety checklist:

- Securely attached all items to ROV.
- Got all hazardous items identified and covered.
- Got all propellers completely shrouded.
- Took care of all sharp and jagged edges on our ROV by filing them down.

Electrical safety checklist:

- All wiring securely fastened and properly sealed to the ROV.
- There are no exposed wires and that all splices in the tether are properly sealed.
- Tether is properly secured at the ROV.
- Our Brushless motors were electrically sealed after purchase.
- There is no exposed wire or copper and all wiring is securely fastened and sealed.
- All splices in the tether were taken care of prior to competition.

Control system safety checklist:

- Anderson Power plugs are used for electrical attachment.
- Our attachment point is connected to a single powersource.
- Circuit breaker is placed in close proximity to our power supply attachment point.
- All electrical components are covered inside our enclosure.
- Proper strain relief and abrasion protection is used for the wires passing through our enclosure.
- Our 120VAC wiring is clearly identified and separated from the DC and control voltages.

- Properly typed connectors are used for for each specific task

Hydraulic system safety checklist:

- Our pressure lines are stamped with the proper 300 psi specifications.
- Our valves meet the minimum pressure rating of 300 psi.
- Our attachment to pressure source is secured.
- We set the max pressure to 150 psi for our pressure regulation.

- The pressure vessels have stamped pressure rating and inspection sticker and can be secured on pool deck.

Safety Procedures

Safety is the primary concern of VMI. All teammates are required to be in proper dress code when working on or around the ROV. The dress code for working on the ROV is, no loose fitting clothes, long pants, closed toed shoes, and hair pulled back. All teammates are trained in safety procedures, to ensure that everyone is comfortable with completing the task assigned. Before working with power tools, teammates are taught how check the tool if it is in working condition, and how to properly use the tool. Along with knowing how the tool operates, and how to safely handle the tool, everyone is made aware where the first aid kit is located. Along with knowing where duct masks and safety glasses are located.

Safety while testing and working on the ROV is where safety is most stressed. Being cautious around the ROV, for not only the safety of the team, but for the ROV. Before the ROV is turned on, all electrical systems are checked. To make sure all wires in the control box are zipped tied down to prevent wires crossing, and allow the wires to be more accessible for repaired. The safety prevents the circuits being overloaded, and potential damage being prevented. After the technical safety check, every station announces that they are ready for the ROV to be submerged in the water, the power switch is flipped. While the ROV is in the water, the tether manager is responsible for making sure that the ROV doesn't get wrapped around the tether. Safety is such a high priority during both testing or building of the ROV.

Critical Analysis

Testing and Troubleshooting

For testing our ROV, we made props based on the product demonstration checklist to make our own personal MATE competition. This allowed us to be comfortable with controlling the ROV, and to practice using the claw to complete tasks. We use pool time time at different locations in our area and we set up props just we would at the competition. This helps us better prepare for what competition day will be like. While we were testing our ROV we decided what role each person would have on the competition day. The different roles on competition day are driving the ROV, being a pneumatic controller, commander, two tether managers, and a co-pilot. Each of these jobs are crucial to ensuring our team is success on competition day. Testing our ROV proved beneficial, as we became familiar with it before the competition starts.

Troubleshooting is a big part of building a ROV. The biggest problems that kept reappearing were problems with our Arduino that controls the motors. Coding an Arduino itself involves troubleshooting, but having four motors being controlled by the Arduino has proven to be a

daunting task. Our team has done an amazing job and pulled off something very few high schoolers can do. This may have been a daunting task at first, but our team feels very accomplished and has learned so much. Another challenge we faced was trying to come up with a design for our control box which houses the viewing screens, the sonar valve, and the Arduino that controls the ROV. This box needs to be big enough to fit everything but small enough to be able to be easily transported. Once we figured out a design and troubleshooted several different options it turned out beautifully. Some strategies that helped us troubleshoot these problems had been going to our mentor, watching YouTube videos, and going to different sites that had help for us. Going to our mentor helped us as we got to see our ROV in a different light which helped us troubleshoot these problems. One of our more successful troubleshooting strategies and techniques was going online and reading articles that had information on how to build an ROV. There was never a dull moment when the wires and sawdust were flying. These problems have given us life long lessons that have made this experience so valuable.

As we were building Galia, our ROV, we started out by deciding what motors we wanted to use. We chose T100 motors from blue robotics and figured out their specifications. After we did this we had taken old wipe containers, foam board, and hot glue to build a miniature 3D version of our ROV. Creating this prototype helped us see what our ROV will possibly look like and what we wanted to add. We couldn't quite test our prototype but we did get to see what different designs would look like. One thing that did benefit us in figuring out the design of our ROV was our team members who were on Scout, who showed us their ROV. The combination of seeing the Scout ROV and building a 3D model helped us figure out different design options. Once we tested our complete ROV it also helps give us an idea of what we should add or take-away to make it work better. That is how our team designed our ROV using different elements to weigh out options.

Challenges

As a brand new team we faced many challenges that we needed to overcome. The first of these many challenges was learning how to use CAD. Our Chief Engineer was brand new to this system and had to learn how everything worked. It was very challenging for him because he was not familiar with the system and was finding it difficult to use. He found a solution to this problem by taking online trainings and spending countless hours outside of team practices learning how to use CAD. Once he was able to use CAD and he understood it he was able to create our ROV in a 3D computer model. This was a difficult task he had to overcome but once it was completed he felt very accomplished. Another challenge we had to overcome was programming the Arduino to be the brains of the ROV. Mekiah is brand new to coding the ROV and had to learn how to use Arduino very fast. As with our chief engineer, Mekiah's solution to the problem was watching online videos and practicing by coding on different websites. Though this was a challenge for him he succeeded in programming the ROV using Arduino. This has been some of

our very defining moments as we have overcome these challenges. One of the most devastating challenges was losing our CFO for two months as she was in and out of the hospital due to health reasons. This was a huge blow to our team and communications because she did a lot of communicating with businesses for donations. This led to our budget become more constrained, but as a team we came together picked up her duties and made sure we managed the budget. Our solution to this challenge had been assigning our CEO and CMO to split the task and work on the budget. We chose to do this because they were the two positions who did not have as much on their plates. Fortunately, our CFO did return and we were so glad to have her back, and that she was healthy. This challenge was the hardest, but we overcame as a team and because of this we have grown so much as a team and as people. Each challenge was met with a solution. We are so grateful we have a team that completed challenges and grew together through them. We adapted and overcame, and having completed our ROV, we are ready to succeed.

Lessons Learned

The biggest lesson learned is on the technical side of things, which was that engineering is not as easy as it looks! Our Chief Engineer had many challenges while building the ROV that gave him great life lessons, since he had never used CAD tools before. This was very difficult for him and he learned so much about troubleshooting problems, which is a skill that he can use later on in life. The biggest skill that he learned from the design process is patience when working with difficult tasks such as building a ROV. Mekiah, our chief technical officer, learned more about serial communication than before. This has given him more life skills that he can use later on. On the organizational skills side our CEO learned what it was like to be in charge. She would tell you that because of MATE she learned how to communicate better with people and how to juggle different tasks. Our CEO will tell you as well that she never thought she could do these things until she did MATE. Now she has these skills that she can take into college and her career. The development of these skills have opened up more options for her now than before. This is another reason why this competition has been a rewarding experience. Our CFO would tell you she learned how to raise funds and communicate with different businesses to sponsor our company. These are skills that become beneficial as you head into the business world and have benefited our CFO greatly. She will also tell you that she has learned to go out of her comfort zone when asking for donations. For her it is really scary to do so and now she can do it confidently without a fear of people saying no. Each of these different skills were developed because of these lessons learned. Each member of our team has walked away with new skills that we did not have before, and we also developed skills that we already had. Each lesson learned though was birthed from a challenge. The development of patience, learning new skills in coding, and learning how to communicate were all developed based on the lessons learned from the challenges we faced. These challenges, lessons, and skills are all beneficial to our team in life and for our future in Science Technology Engineering and Math (STEM).

Future Improvements

Reflections

Looking over the past months of Valor Maritime International, we have accomplished many amazing tasks, though they were not completed without failures that could have been avoided. The largest problem that we were confronted with was our lack of diligence to stick to deadlines. Even though we had plenty of time to complete the finish our ROV and our documentation, it would have been better to have more time to test the ROV in the pool before the MATE competition. Another problem that was encountered was communication between team members. There are six people that make up Valor Maritime International, whose specific roles were sometime forgotten, which resulted in tasks not being accomplished, because no one knew who is doing which task. Also the lack of organization doesn't help our cause either. Since then we have clearly defined our roles, and have made a central drive where documentations is stored, which has made this last month more streamlined for daily processes. Since none of the team members will graduate this year, we are expecting everyone to come back next year to compete. We are putting in place plans for next year so that we do not face these same problems. One of these new implications is placing a stricter protocol for following deadlines. This will make it easier for us to be prepared for the competition as everything will be done beforehand. Another protocol set in place is making sure we start working on our ROV right away, rather than procrastinating. This will give us the opportunity to have more pool time before the competitions so we are pros by competition day. These are the main things we want to fix and improve on before next year.

Accounting

Budget

Our Chief Financial Officer, Meaghan Giard, budgeted out how much everything would cost in the first weeks before building our ROV. She created a list of supplies and how much each supply would cost, how much of each supply we needed, and whether it was going to be bought, donated, or re-used products from our science department. Our budget was limited to how much we could fundraise. This year we were able to get our most expensive supply, Delrin, donated by Micron-Laser. This made it easier to follow our budget and stay on the cheaper side of buying things. The organization of our budget was done by seeing the supplies need and planning for how much each cost. Once we figured out how much supplies costed we planned how much we need to fundraise. Our overall total cost had been around \$3000 which was quite a lot. However, once our \$2000 Delrin was donated we only needed to raise about \$1000. We did raise half of

our goal and are still fundraising as we speak. Though this is a long process we are very grateful that our team has followed our budget as closely as we can. Our team unanimously made this decision, and it has benefited us very greatly

Cost Accounting

Please see the appendix for the spreadsheets on the Budget and the Actual Costs so far. We anticipate that additional costs will occur in the weeks leading to the international competition.

Donations

We would like to thank the following people for their contributions

Inline CC	\$250.00
Plumbing Materials Supply	Props
Therapeutic Associates Physical Therapy	\$250.00
Valor Christian School International	Money, supplies, and space
Maple Valley Plumbing	\$100.00
Micron Laser	\$2000 worth of laser cutting
Rob and Kathy Durkee	\$500
Oregon Regional MATE Competition	\$1500
Onpoint Community Credit Union	\$1000

Acknowledgements

We would like to thank the following people for their contributions

Inline CC	\$250.00
Plumbing Materials Supply	Props
Therapeutic Associates Physical Therapy	\$250.00
Maple Valley Plumbing	\$100.00
Valor Christian School Int	Space and Support to work
Rob and Kathy Durkee	Donations
Micron Laser	\$2000 worth of laser cutting
Onpoint	\$1000
Oregon Regional MATE	\$1500
Holly Neill	Provided Moral Support as our Mentor
Paul Donelson	Providing help with documentation
The MATE Center	For organizing this competition

Sources and Citations

Huber, Mark. "Diving Robots Could Recover Air France 447's Black Box." *Popular Mechanics*, Popular Mechanics, 14 Nov. 2017, www.popularmechanics.com/technology/robots/a4339/4320244/.

"How ROVs Are Used in the Hydroelectric Power Industry." *Aquabotix Technology*, www.aquabotix.com/news/how-rovs-are-used-in-the-hydroelectric-power-industry.

"Subsea Instrument Deployments: Methodology and Techniques Using a Work Class Remotely Operated Vehicle (ROV) - IEEE Conference Publication." *Design and Implementation of Autonomous Vehicle Valet Parking System - IEEE Conference Publication*, Wiley-IEEE Press, ieeexplore.ieee.org/document/726340/

Budget**Reporting Period**

School Name:	Valor Christian School International	From:	11/1/17
Instructor:	Holly Neill	To:	5/24/18

Income Over Project

Source	Type	Date Recieved			Value	Cost
Oregon Ranger Regional Grant	Grant	4/2018				\$ 1,500.00
OnPoint	Grant	5/2018				\$ 1,000.00
Inline Commercial Construction	Donation	12/2017				\$ 250.00
Theraputic Associate	Donation	12/2017				\$ 250.00
Maple Valley Plumming	Donation	12/2017				\$ 250.00
Rob and Kathy	Donation	1/2018				\$ 500.00
Micron Laser	Services	2/2018			\$ 2,000.00	
Plumbing Material Supply	Supplies	12/2017			\$ 200.00	
				Totals:	\$ 2,200.00	\$ 3,750.00
						\$ 5,950.00

Expenses

Category	Type	Description/Example			Projected Cost	Budgeted Value
Hardware	Purchased	Tech Flex			\$ 50.00	\$ 50.00
Hardware	Purchased	Blue Robotics Motors (4)			\$ 576.00	\$ 150.00
Hardware	Purchased	Delrin Sheets			\$ 100.00	\$ 130.00
Electronics	Purchased	Cameras (6)			\$ 20.00	\$ 31.00
Hardware	Purchased	Seahorse Container(1)			\$ 50.00	\$ 48.00
Hardware	Purchased	Epoxy			\$ 13.00	\$ 12.00
Electronics	Purchased	Adriono Board (2)			\$ 10.00	\$ 9.00
Electronics	Purchased	50ft Extension Cord			\$ 30.00	\$ 29.99
Hardware	Reused	Pneumatics Tubing			\$ 15.00	\$ 14.00
Hardware	Reused	Air Compressor			\$ 60.00	-
Hardware	Donated	3D Filament			\$ 15.00	-
Electronics	Purchased	Wiring			\$ 22.00	\$ 15.00
Hardware	Purchased	Hardware			\$ 20.00	\$ 15.00
Hardware	Purchased	Solenoid Valve(2)			\$ 10.00	\$ 20.00
Hardware	Purchased	Pneumatics Actuator			\$ 20.00	\$ 20.00
Travel	Purchased	House Rental			\$ 2,000.00	\$ 1,951.00

Travel	Purchased	Airplane Tickets			\$ 200.00	\$ 215.00
Travel	Purchased	Gas			\$ 150.00	\$ 200.00
Travel	Purchased	Food			\$ 850.00	\$ 800.00
General	Purchased	Marketing Materials			\$ 250.00	\$ 275.00
Hardware	Donated	Lasercutting of Delrin			\$ 2,000.00	-
Hardware	Purchased	Control Box			\$ 50.00	-
Electronics	Purchased	Cable Fittings			\$ 15.00	-
Hardware	Reused	Power Supply			\$ 89.00	-
					Total Income	\$ 3,750.00
					Total Expenses	\$ 3,945.99
					Total Expenses-Reuse/Donation	\$ 2,362.00
					Deficit	\$ 195.99

Project Costing	Reporting Period	Total Raised	\$ 5,950.00
School Name Valor Christian School International	From: 11/1/17	Total Spent	\$ (5,677.38)
Instructor: Holly Neill	To: 5/24/18	Final Balance	\$ 272.62

VMI Budget						Running Balance	
Date	Type	Category	Expense	Description	Source/Notes	Amount	Balance
11/1/2017	Reused	Hardware	Air Compressor	to run the pneuematics	Pneuematics	\$ (89.00)	\$ (89.00)
11/1/2017	Purchased	Hardware	Blue Robotics Motors	Motor power	to use to power robot	\$ (476.00)	\$ (565.00)
11/1/2017	Purchased	Electronics	Blue Robotics Speed Controls	to regulate the motors	to run the robot	\$ (100.00)	\$ (665.00)
12/1/2017	Purchased	Hardware	3D Filament	Print Motor Covers	Print Motor Covers	\$ (15.00)	\$ (680.00)
1/10/2018	Purchased	Electronics	Adriono Board (2)	Robot Brain	Robot Brain	\$ (21.00)	\$ (701.00)
1/10/2018	Purchased	Electronics	Seahorse Container	The container for the Robot	Robot Brain	\$ (48.00)	\$ (749.00)
1/22/2018	Part Donated	Electronics	Monitor	Computer monitor	Control System	\$ (50.00)	\$ (799.00)
2/1/2018	Purchased	Hardware	TechFlex	teather manager	teather management	\$ (48.00)	\$ (847.00)
2/14/2018	Purchased	Electronics	Wiring	To complete the control box	Control Box	\$ (22.00)	\$ (869.00)
2/15/2018	Purchased	Hardware	Delrin Sheets	Body of Robot	sheets for robot body	\$ (143.00)	\$ (1,012.00)
2/27/2018	Part Donated	Hardware	Cutting of Delrin	Delrin is laser cut to specification	donated by Micron Laser	\$ (2,000.00)	\$ (3,012.00)
3/1/18	Purchased	Electronics	Relay Module	Pneuematics	Gripper System	\$ (14.95)	\$ (3,026.95)
3/1/18	Purchased	Electronics	Power Distribution Fuse Block	Robot Brain	Control System	\$ (12.96)	\$ (3,039.91)
3/1/18	Purchased	Electronics	Video Splitter	Control Box	Control Box	\$ (5.00)	\$ (3,044.91)
3/1/18	Purchased	Electronics	7 Blade Trailer Plug	Control Box	Control Box	\$ (22.00)	\$ (3,066.91)
3/1/18	Purchased	Electronics	Multi-Outlet Exstention Chord	Control Box	Control Box	\$ (30.00)	\$ (3,096.91)
3/4/2018	Purchased	Hardware	Hardware	Ace Harware Run!	Control Box	\$ (20.00)	\$ (3,116.91)
3/4/2018	Purchased	Hardware	Solenoid Valve(2)	to complete pneumatics	Pneuematics	\$ (9.99)	\$ (3,126.90)
3/4/2018	Purchased	Hardware	Pneumatics Actuator	pneumatics parts	Pneuematics	\$ (17.50)	\$ (3,144.40)
4/3/18	Purchased	Electronics	Fuses(6)	Robot Brain	Safety	\$ (13.98)	\$ (3,158.38)
4/3/2018	Purchased	General	Epoxy	to waterproof the robot	Robot Brain and Safety	\$ (12.00)	\$ (3,170.38)
4/15/18	Purchased	General	Corn starch(3)	Protoputty	Gripper System	\$ (20.00)	\$ (3,190.38)
4/15/18	Purchased	General	Silicone(5)	Protoputty	Gripper System	\$ (27.00)	\$ (3,217.38)
4/15/18	Purchased	General	Food Coloring	Protoputty	Gripper System	\$ (25.00)	\$ (3,242.38)
4/17/2018	Purchased	Electronics	Video Cameras	4 backup cameras	used for video system	\$ (92.00)	\$ (3,334.38)
4/20/2018	Purchased	General	Marketing Display	Competition Poster	Competition Day Supplies	\$ (87.00)	\$ (3,421.38)
4/21/2018	Purchased	General	Team T-shirts	Marketing	Competition Day Supplies	\$ (80.00)	\$ (3,501.38)
5/19/2018	Purchased	Travel	House Rental	lodging	MATE International	\$ (1,951.00)	\$ (5,452.38)
5/23/2018	Purchased	Travel	Plane Tickets	Fly Amber Up and Jacob Down	plane tickets	\$ (225.00)	\$ (5,677.38)