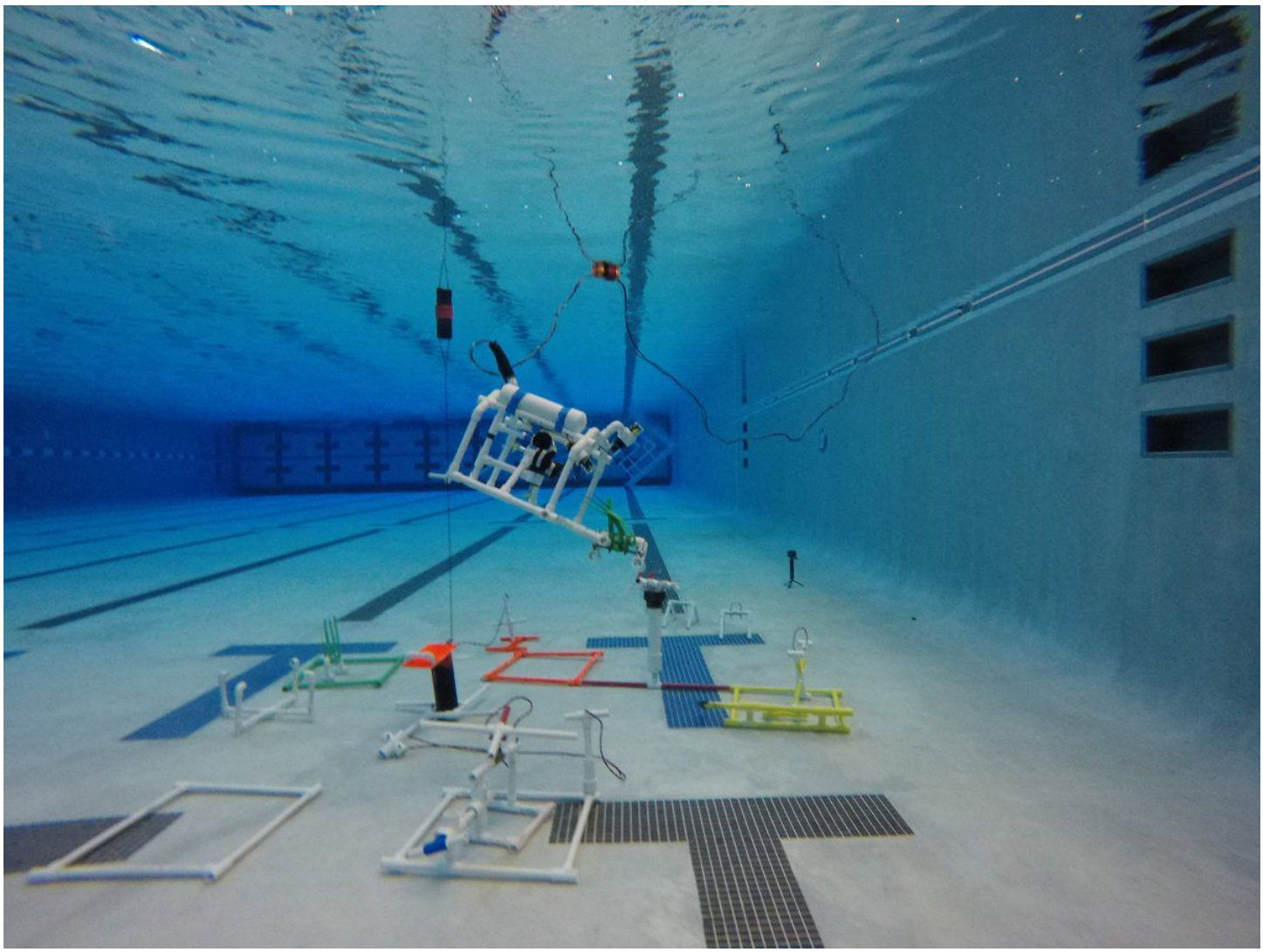
# MATE 2018 Competition RANGER


Gavin Bentley (Class of 2020) — CEO, Head of Electrical, and Mechanical Engineer
Quintin Folkner (Class of 2020) — VP, Pilot, Head of Mechanical and Electrical
Braden DeBruin (Class of 2021) — Head of Documentation
Ashlee Wall (Class of 2021) — Head of Graphic Design and Safety Officer
Shelby Rose (Class of 2020) — Public Relations Officer
Richard Vautrin -Hickman (Class of 2019) — CAD Engineer
Mackenzie Bolton (Class of 2018) — Business Manager

Instructor:
Antonia Adinolfi
Consultants:
Robert Matson (Naval Engineer)
Phil Bentley (Project Engineer)
Gregg Folkner (Carpenter)

Kingsport, Tennessee



R-Matey's Rov: Archi

## Table of Contents

# Abstract

R- Mateys is an owned subsidiary of Dobyns Bennett EXCEL, Kingsport, Tennessee. R-Mateys undertakes technological design, development and fabrication in the underwater environment. Our ROV Archi, is specifically configured to support the need for ROVs in sea exploration, as well in the confined and precarious conditions of locating and exploring crashed airplanes. Archi is equipped with a multitude of tools; each tool designed, tested, and modified with specific missions and goals in mind. The ROV has the ability to assist in underwater search and recover, remove debris, install alternative, clean energy sources, as well as measure the magnitude of earthquakes.

As the year proceeded, many obstacles were overcome. This includes, but is not limited to, new technology, inner-club miscommunication, teamwork, and learning as a new company all around. Size and weight restrictions are not new to our company; however, the ROV's design revolved around this idea notably. This year, as well as focusing on various restraints, the engineering personnel targeted the optimization of as much space as possible in relativity to Archimedes' principle.

Our company accomplished the tasks assigned in this year's competition through ever-growing teamwork, perseverance, and, of course, with specialized tools. A light frame from PVC pipe and 3-D printed parts allow Archi to remain under 5.4 kg in weight. This enables a single person to easily transport the vehicle.

# Design Rationale

Our MATE underwater robotics company, R-Mateys, designed a ROV capable of executing underwater missions relating to, but not limited to a plane crash and installing insulation of energy sources. We are able to move and control our robot underwater, and complete missions such as removing debris, maneuvering around debris and many other task.

Our company's ROV was influenced by a previous robot in which we worked on, the Triggerfish.  While building the Triggerfish, We as a company picked up on the design, tools and process of building the Triggerfish, which we took into account while building our Robot.

A few things that we did change in order to make our robot better was change the design of the frame. Our engineers decided to go with an orthogonal or cube design. However, they noticed that the was unnecessary space being wasted in the top corners. To solve this, the engineers cut of the top corners and set them at an angle in to make essentially a modified trapezoidal frame. This saved space and allowed the company to place a sway motor. The sway motor allows for small, precise adjustments and was essential for Archi's performance.

# Tether

The tether is a vital part of any ROV system, as it is the sole connection from the control box to the ROV. If something is not properly connected inside of the tether, then Archi will not run properly. However, there is tradeoff in using this tether. The cable is heavier than individual conductors because the conductors are paired and insulated inside the cable. The trade-off comes with enhanced safety and convenience. R-Mateys is very confident in the tether and its durability. All connections to the machine are sealed with hot glue inside heavy duty heat shrink. The tether exit point from the ROV has also been fitted with 2 points of strain relief.

# Frame

Our Frame must be able to allow water into the system, protect the wires, and be light enough to be maneuverable in the water along with even distribution of weight. It also has to be able to handle the weight of the motors along with the cameras.

To design our frame to meet our goal and expectations we went through many prototypes and sketches throughout this process. Our final design has a pentagonal frame with the top pieces tilted inward. Compared to our beginning design which originally had a simple cube design.

Some of the issue we came across while building our ROV was clustering. There was simply not enough room for all our ideas to fit. So, to counteract that we slanted the PVC pipes in the

middle, which are holding the 2 of 4 motors, to make it more compact. This will allow the Engineering Personnel, Quintin and Gavin, constructing the frame. ROV to traverse the confined and precarious locations typically connected with underwater crashes and maneuvering around the Debris. Towards the beginning, the frame of the ROV was uneven, so we had to take it completely apart and rebuild; However, this provided us with another chance to explore possibly better ideas.

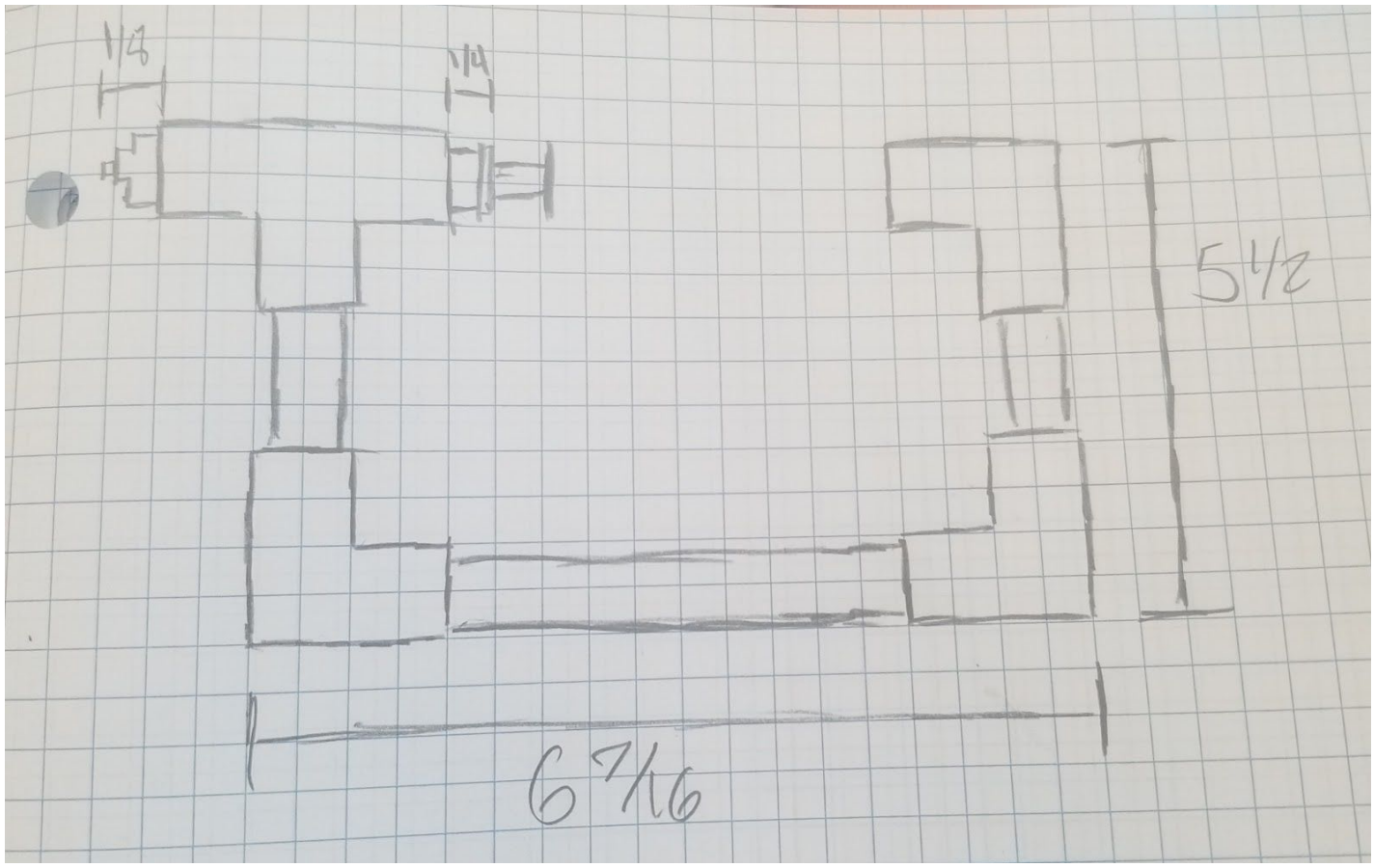
# Cameras

Our camera system is equipped with 2 cameras. Our company choose to use the cameras supplied by the SeaMATE TriggerFish Video System Kit. These cameras are small, lightweight, colored and large perspective. Since they are lightweight they will not affect the ROV buoyancy. With the large perspectives this will allow our pilot to see what we are doing and where we are going. Our cameras are placed in the middle of the top front frame, angled down and inward so is is centered on the tools as to ensure everything is done with precise measurements and complete confidence.

# Simple Hydraulic Claw

For our claw we used syringes to act as our locking mechanism/grabber. The claw is consisted of ½ inch PVC, two 90 degree fittings, a ½ tee that holds the syringe, and a cross that connects it to the ROV. The claw has a gap long enough to lock the end of the syringe in place. Although, the claw doesn't act like a regular claw; it is designed to act like a closed rectangle that will lock the objects in place. This allows for the ROV to grip and move objects or latch onto and drag. The claw is controlled by simple hydraulics that is ran up to the control station and controlled by the co-pilot.

# Mechanical Drawing of Claw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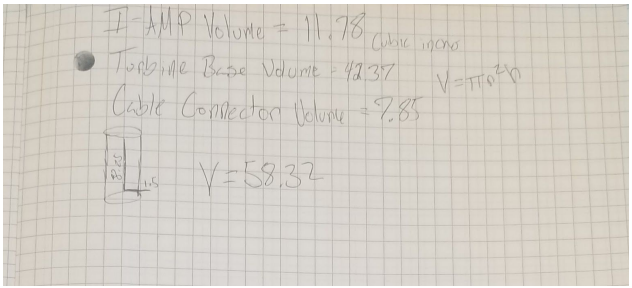
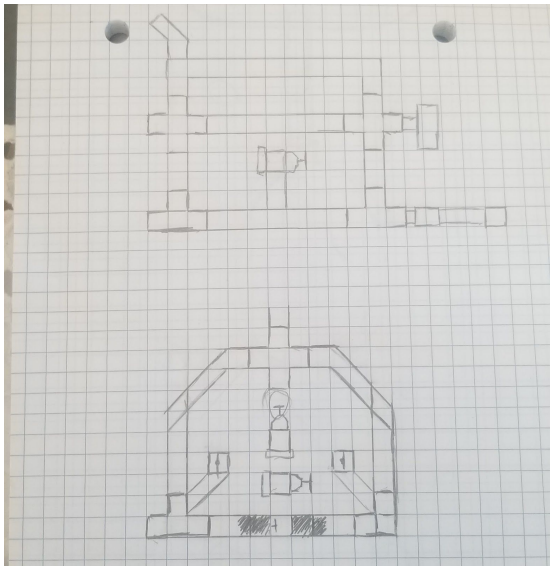

I-AMP Volume = 11.78 Cubic inches
Turbine Base Volume = 42.37
V=π r² h
Cable Connector Volume = 7.85
V=58.32

# Ballast System

The company eventually ran into problems with lift. The ROV simply couldn't lift when we had grabbed an object with the claw. Our engineers had a two options: either get a better vertical motor. So, convert from the 500gph bilge pump to the 1000 gph bilge pump. They also had the option of configuring a ballast system to pump air back into the vehicle. They ultimately decided to go with the ballast. We used the geometry of a cylinder to determine its volume and calculated off of every prop about how much each one would weigh. So to counteract the weight, we would have to displace that water or weight with air to make the ROV more positively buoyant.

# Design process

In February of 2018, our company began the process of constructing our very own ROV.  Our company began this process by talking out questions, thoughts and concerns. This was done by splitting up the competition manual in to certain sections and assigning them to groups where we spent thirty minutes to an hour talking aloud our ideas based on the section we were given. Then we met back up as a unified company to then discus our ideas with the other groups. This helped us make a plan we were confident in.



Our company spent time reviewing the build, design and materials of a previous robot we worked on and this also gave us some great ideas to use in our final build. We took into account the size and weight after the competition manuel released. We then regrouped and discussed our plan furthermore making sure the requirements were met.

The following week we spent building skills in soldering, safety,  and handling power tools. In order to insure we had all the skills necessary to build and control our robot while also educating ourselves in a field we may have had little to no experience in. This allowed us to fill in places needed if a person were not able to be at a meeting or resigned from the team.

The weeks after that our company constructed a plan, sketch and gathered materials that would be used in the process or on the ROV used in the competition. Next, in the beginning of March, our company moved location from Dobyns Bennett EXCEL to Streamworks in downtown Kingsport. This is where we spent the majority of our time building our ROV. They had helped provide tools and the space necessary for the building process.

# Fundraiser

Fundraising provides a foundational component for the team to work together and support our cause. Our team has several expected fundraising events. For example, spirit night at Barberitos occured on the 3rd of May. We also had a spirit night on April 19th, where we spent five hours greeting, serving, and helping in an effort to bolster nightly revenue as we received ten percent from each final purchase. A donation of forty dollars was given to our R-MATEYs team. We expect to raise additional funds before International Competition.

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D-B EXCEL Underwater Robotics Program

To Our Good Friends,

Marine Advanced Technology in Education (MATE) is an underwater robotics program that uses remotely operated vehicles to engage students in STEM and expose them to careers in science and technology. D-B EXCEL's MATE Team is the first underwater robotics team in Tennessee and consist of sixteen students or "entrepreneurs" who design and build an underwater ROV to navigate a series of mission-specific and scenario-based tasks. To learn more about MATE, please visit the following address: https://www.marinetech.org/rov-competition-2/

We, the D-B EXCEL MATE Underwater Robotics Team, the R-Mateys, have recently had the good fortune of winning the regional competition, and have qualified for the 2018 International Competition - *Jet City: Airplanes, Earthquakes, and Energy*, which highlights the role that ROVs play in supporting underwater archaeology, seismology, and renewable energy activities in open waters. The 17th annual MATE international ROV competition will take place June 21-23, 2018 at Weyerhaeuser King County Aquatic Center in Federal Way, WA, USA, with the awards ceremony taking place at the Hotel Murano in nearby Tacoma.

While we are excited to represent the Southeastern region, we need your support to help in covering some of the trip's cost. With Seattle being over 2,500 miles away, the team will be flying into the city on June 19th and departing the 24th. The seven day adventure will be full of maintenance checks, competition preliminaries, and underwater obstacles for Archi, our remotely operated vehicle. In order for this trip to take place the team is going to have to raise over $12,000 dollars, currently we have raised $6,110 dollars and are hosting a couple of fundraising events - listed below. If you would like to support the R-Mateys in our transcontinental trip to assert our continued dominance within the ROV arena, please contribute to any or all of the following fundraisers:

***Family Night at Putt-Putt Fun Center:***
- Location: 346 W. Stone Drive, Kingsport, TN
- **May 24th ( 6 - 8 pm)**
- Ticket Information/Cost: $6/person
- "Hole" Sponsorships - $100/hole
- Concessions will be available

**All proceeds (including $3/person) will go to the D-B EXCEL MATE Team to help with travel/expenses to Washington*

***STREAMWORKS' Destination STEM Station:***
- Location: 252 Broad St. (the corner of Broad and Center St.) Kingsport, TN.
- Cost: $25/child for 3 hours of fun-filled STEM activities.
- **May 25th (6 - 9 pm) June 8th (6 - 9 pm)**

**40% of each ticket purchased will go to the D-B EXCEL MATE Team to help with travel/expenses to Washington*

***Sponsor a Student for the Trip:***
- Estimated cost per student for flight, hotel and daily expenses is $1,000.00.
- Student sponsors will be featured on the R-Matey's shirts and marketing display.

**Please Make all Checks Payable to D-B EXCEL Underwater Robotics*

Sincerely,
The R'Matey's

tsin
Tennessee STEM School Designation
TN Department of Education

# ROV Budget

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| | | | | | |
| **Income** | | | | | |
| | | | | | |
| **Source** | | | | **Amount** | |
| Fundraisers/ Donations | | | | $ 1,650.00 | |
| Streamworks Sponsorship | | | | $ 5,000.00 | |
| **Expenses** | | | | | |
| **Category** | **Type*** | **Description/Examples** | **Projected Cost** | **Budgeted Value** | |
| Hardware | Purchased | PVC pipe, tees | $50 | $ 50 | |
| Electronics | Purchased | SeaMATE TriggerFish ROV Kit (Rev 3) | $ 700.00 | $ 700.00 | |
| | Purchased | Wires | $20 | $20 | |
| General | Purchased | Marketing material | $ 10.00 | $ 10.00 | |
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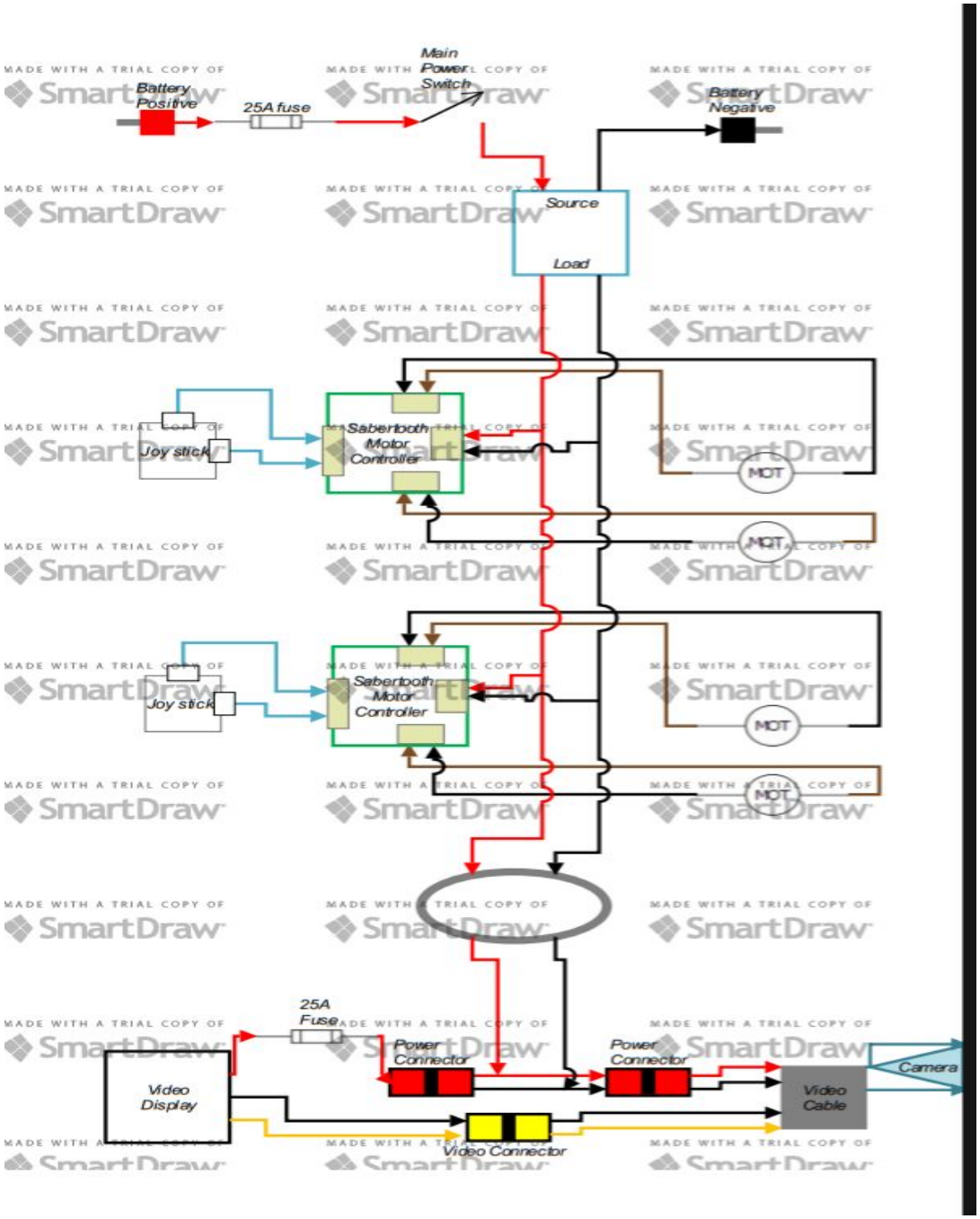
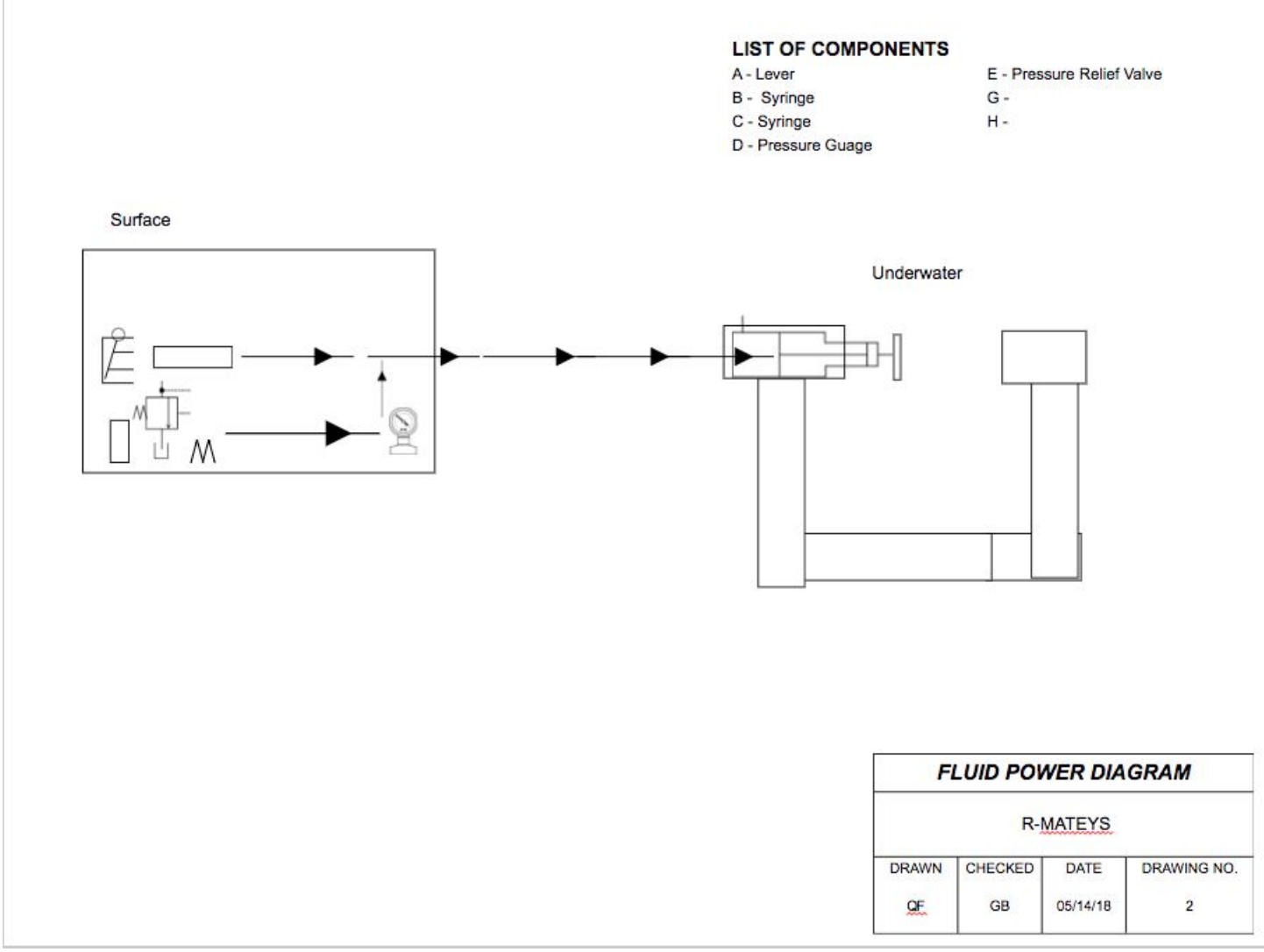
| | | | Total Income: | $7,580.00 | |
| | | | Total Expenses: | $790.00 | |

# Electrical Diagram



# Hydraulics Diagram




# Project Management

To ensure that the company had enough time to assemble Archi, the following work schedule was put into play. On weekdays, the company would meet at Streamworks to work from 3 pm to 8 pm, Saturday workshops were held for those who could attend from 7am to 2pm. As schedules

opened up due to the approaching summer, the members of R-Mateys started meeting up to do fundraisers to gain money for travel expenses and future builds. This consisted of spirit nights through restaurants, open nights at the local stem gym/makerspace, and an occasional putt-putt tournament.

# Safety in the Workplace

R-Mateys Robotics regards safety as a top concern. It is included in our contract: “I understand and will abide by the safety rules that must be followed during the process of building, designing, and operating a robot.” This is one of the many things listed our members were required to initial and sign in order to work for our company. This was to insure all members safety with every aspect included. Every staff member is required to attend a workshop where they were instructed on safety and operations, along with location of first-aid. We built our ROV with Safety of ourselves and other in mind. In order to guarantee safety, our company follows certain precautions, By breaking down into job types of electrical, mechanical, and pool work, our company determined some potential hazards in the workplace and what procedures to take while on the job for more effective prevention.

# Safety Checklists

## During Construction

- ❏ Close-toed shoes
- ❏ Long pants
- ❏ Tied back hair
- ❏ No loose clothing
- ❏ Safety glasses worn while using tools or soldering
- ❏ Proper air ventilation at all times
- ❏ Respirators when working with anything with fumes
- ❏ Proper workshop behavior (no running / horseplay)
- ❏ Proper training on all power tools

## Pre-mission Checklist

- ❏ All items on ROV are properly secured
- ❏ No exposed wiring or propellers
- ❏ All wiring is secured
- ❏ Tether is secured to both ROV and control box with proper strain relief
- ❏ Tether is uncoiled and untangled on deck
- ❏ Hair is tied back
- ❏ Deck crew is wearing close-toed shoes and long pants
- ❏ Main power switch is off until all electrical connections have been connected, checked, and double checked
- ❏ Main power switch is powered on once all deck crew members say “All clear”

# Challenges

During the building process of the ROV, we discovered that we had run into many issues involving building, money, and time. This caused us to go back and take apart the robot and rebuild. This then led into time restraints, leaving us with little less then a month to finish building and test our robot before regionals. All of these factors then contributing to the fact, we have a low budget. Since our company has a low budget, we were limited on supply and tools needed to work on the ROV. A constant we noticed was a lack of communication. It was rather difficult to set up meetings unless it was known in a long advance.

# Troubleshooting

During the fabrication and testing of our ROV, our company ensured testing of all mechanical and electrical components. Electrical systems were tested solely and then tested together until all features worked fine. Problems happen sometimes from simple errors, human or random. Therefore, a plan was made to find quick and reliable issues for the problems faced. There are several techniques that our company use in troubleshooting problems. When an issue appears, we begin identifying the problem by tracing the problem back to the root. Problems can be caused by loose connections, leakage resulting in electronics damage, simple human errors, etc.

Our first problem was that we placed the motors on backwards after we already had them soldered the together. This caused us to cut the motor wires and add extensions for the wires to reach the entrance point into the frame. Then we had an improper place of the strain relief leading us to spend most of a week fixing the issue, leaving time strain. Towards the end we then had bad joysticks, which we had to move the motor then a bad camera. Be these were all gladly fixed with time to spare.

Tips followed as a standard approach to solving
Problems:

- Follow the ROV checklist.
- Analyze symptoms.
- Locate factors that contribute to problem.
- Isolate the source of the problem.
- Define a plan.
- Check and recheck to ensure everything is running smoothly.

# Improvements in the Future

To improve the efficiency of R-Mateys in the future, the company will need to work on better communication. This will make sure that every member will be able to know when meetings are and know when to show up. Another improvement would be better time management. Our company ran very low on time as we ran into many inconveniences. Stricter application processes will also be implemented as to ensure that those allowed on the team will pull their weight. Fundraising would also help a lot as funding was low. Another must for the future is teaching the company members about the other parts of the job. Members need to be well versed and versatile in a multitude of roles to ensure that no job is left incomplete.

# Learning Opportunities/ Lessons Learned

In the time from the beginning of the team to the end, many members learned much about the technological side of the competition allowing us to expand our knowledge on the variety of topics used. Integrating waterproofed motors, allowed us to learn how these motors worked along with how to use them. We tried a variety if different methods to make this possible, allowing us to test a variety of PVC and other materials to stop leakage. This took a lengthy amount of time; however it allowed much time to learn.

# Team Building Skills

When working with a company you need patience, dedication, and most importantly, communication. During the time of working together, the company not only developed these skills, but also many more. Working in a close environment requires these skills to be used. As time went on, patience grew for each member. Some members, namely Gavin Bentley and Quintin Folkner, exhibited extreme dedication which included pulling late night workshops only to show up for the 7 a.m. on the following Saturday. By the time of internationals, the R-Mateys team grew as not only a company, but as a family as well. The members grew to know each other and helped each other to face and overcome their challenges.

# Acknowledgements


## *R-Matey's Robotics would like to thank the following benefactors:*

- Antonia Adinolfi, for his technical/non-technical assistance, and being supportive all the time.
- Gregg Folkner, for his generous help to our mechanical team.
- Streamworks, for providing space and a $5000 sponsorship.
- Dennis Courtney, for organizing the local and regional competitions and his never ending enthusiasm to see children learn.
- Kingsport Aquatic Center and Marriott, for giving us access to their pools 5 days a week.
- Eastman, for allowing the company access to their 3D printers
- Dobyns Bennett Excel, for providing space and endless support through the company's journey.
- Our parents, for providing unrelenting support to us.
- Phil Bentley, for his help to our electrical engineers
- Robert Matson, for his support and help with buoyancy and hydraulics.