



# Daedalus



Sea-Tech 4-H Club located in Mt. Vernon, WA, USA  
1,965 km from Long Beach College, CA

## Proposal to the Port of Long Beach

Priya Kumar – CEO  
Spencer Cocheba – CFO  
Gunnar Hogle – Marketing Director  
Isaiah Houghton – Director of R&D  
Varick Andrews – Director of Design  
Cooper Ristow – EHS Officer

Lee A. McNeil – Mentor  
Marty Houghton – Mentor

# 1. Abstract

The Port of Long Beach, one of the world's busiest shipping ports, has issued an RFP (request for proposals) for an ROV (remotely operated vehicle) that can complete a variety of tasks in the confined and unpredictable conditions of the port. Tasks include construction of an underwater Hyperloop for transporting cargo at high speeds while reducing cost and pollution caused by modern shipping methods. The port also has their water and light show attraction which requires routine maintenance. Due to high concentrations of heavy metals and risk to organisms, the port has an environmental clean-up project which requires an ROV to remove contaminated sediments from the area. To be able to monitor and track 82.3 million metric tons of cargo every year, ROV are needed for a pilot program to track containers. Team Daedalus responded to the RFP and strived to produce an ROV that was adept at all aspects of this year's mission, "Port Cities of the Future," while prioritizing simplicity. Our mission tools include an electrical three-actuation claw, an aluminum agar collection device, bluetooth receiver module, valve rotation device, and red LED (Light Emitting Diode) which simulates a Raman laser. The ROV is also equipped with four thrusters, LED lights to provide visibility, and three cameras to provide situational awareness in the conditions of the port.

# 2. Introduction

Daedalus is one of three teams that are a part of Sea-Tech 4-H, a 4-H Club based in Mount Vernon, Washington. The club was founded in 2000 by Lee McNeil as a home school project and became a 4-H club in 2001. In 2007, the club discovered MATE (Marine Advanced Technology Education) and began competing in the MATE ROV Competition. Sea-Tech has fabricated 53 ROVs and participated in MATE competitions with 36 teams. Sea-Tech's goal has been to promote education and produce functionally and aesthetically impressive vehicles that can be used both inside and outside competition.

Team Daedalus is composed of three returning Explorer team members and three Ranger team members with 28 years of combined experience. Utilizing the cumulative experience the team has built the Daedalus ROV. It is designed to be compact and simple, while still promoting maneuverability and manipulative capabilities to complete the missions described in the MATE 2016 Explorer Competition Manual. The team hopes to eventually take ROV Daedalus to a lake for a real world experience.

# Table of Contents

<b>1. Abstract</b> .....	<b>2</b>
<b>2. Introduction</b> .....	<b>2</b>
<b>3. Company Information</b> .....	<b>4</b>
<b>4. Design Rationale</b> .....	<b>5</b>
4.1 Frame and Buoyancy .....	6
4.2 Propulsion System .....	6
4.3 Mechanical Systems .....	7
4.4 Video System .....	8
4.5 Shore-side Controls .....	8
4.6 Ship-side Controls .....	9
4.7 Mission Tools .....	9
4.7.1 Claw .....	9
4.7.2 Agar Collection Device .....	9
4.7.3 Bluetooth Receiver Sensor .....	10
4.7.4 Raman Laser .....	10
4.7.5 Valve Rotation Device .....	11
<b>5. ROVs and Port Cities of the Future</b> .....	<b>11</b>
<b>6. Safety</b> .....	<b>12</b>
<b>7. Project Management</b> .....	<b>12</b>
<b>8. Expenditure Summary</b> .....	<b>13</b>
<b>9. Testing and Troubleshooting</b> .....	<b>14</b>
<b>10. Critical Analysis – Challenges</b> .....	<b>14</b>
10.1 Non-Technical Challenges .....	14
10.2 Technical Challenges .....	15
<b>11. Future Improvements</b> .....	<b>15</b>
<b>12. Reflections</b> .....	<b>16</b>
<b>13. Inspiration</b> .....	<b>16</b>
<b>14. Acknowledgements</b> .....	<b>17</b>
<b>15. References</b> .....	<b>17</b>
<b>16. Appendix</b> .....	<b>18</b>
Appendix A: SID .....	18
Appendix B: Safety Check List .....	19
Appendix C: ROV CAD Mode20	

# 3. Company Information



Photo Credits: Shaan Kumar

## Priya Kumar

Company Role: CEO

Project Responsibilities: Mechanical Systems

Poolside Role: Tether Tender

This is Priya's fifth year participating in Sea-Tech 4-H and the MATE competition. Driven by ambition, her resourcefulness and willingness to take on challenges is admired. At sixteen, she is taking advanced classes as a homeschooler. She plans to begin Running Start at Skagit Valley College and is interested in pursuing Biomedical Engineering at university.



Photo Credits: Priya Kumar

## Spencer Cocheba

Company Role: CFO

Project Responsibilities: Ship-side Controls

Poolside Role: Pilot

This is Spencer's sixth year in Sea-Tech 4-H and seventh year participating in the MATE competition. His passion for science, engineering and technology contributes to the team's success. Spencer is an eighteen year old homeschool student, who regularly attends a technical academy. He plans to pursue Software Engineering at university.



Photo Credits: Priya Kumar

## Gunnar Hogle

Company Role: Marketing Director

Project Responsibilities: Shore-side Controls

Poolside Role: Mission Specialist

This is Gunnar's fifth year participating in Sea-Tech 4-H and the MATE competition. Determined to meet deadlines, his ability to take on any work required to finish a job is honorable. At nineteen, he is completing an Associate's in Computer Science and Engineering at Skagit Valley College. He plans on continuing his study in Computer Science at university.



Photo Credits: Priya Kumar

## Isaiah Houghton

Company Role: Director of R&D

Project Responsibilities: Video and Sensor Systems

Poolside Role: Science Officer

This is Isaiah's third year in Sea-Tech 4-H and his fourth year participating in the MATE competition. His ability to research and work on a task until it is perfected is respected. At eighteen, he is graduating high school as a homeschooled student. He plans to attend Skagit Valley College then pursue Mechanical Engineering at university.



Photo Credits: Priya Kumar

### **Varick Andrews**

Company Role: Director of Design  
Project Responsibilities: Structural Systems  
Poolside Role: Mission Commander

This is Varick's fourth year participating in both Sea-Tech 4-H and the MATE competition. His passion for engineering, determination and persistent attitude has made him an asset to the team. At eighteen, he is graduating from Mount Vernon High School and plans to pursue a degree in Mechanical Engineering.



Photo Credits: Priya Kumar

### **Cooper Ristow**

Company Role: EHS Officer  
Project Responsibilities: Propulsion Systems  
Poolside Role: Manipulator

This is Cooper's third year participating in Sea-Tech 4-H and the MATE competition. His contribution in knowledge of electronics, attained from building hobby quad copters, makes him a valuable team member. At fifteen, he challenges himself through the Washington Virtual Academy. Cooper would like to go on to study Aeronautical Engineering at university.



Photo Credits: Unknown

### **Lee A. McNeil**

Mentor

Lee A. McNeil founded Sea-Tech 4-H Club in 2001, and has participated in MATE for eleven years. His loyalty and constant contributions allow our club and team to be the best that we can. Lee is a structural test engineer with Boeing Test and Evaluation, (BT&E), currently working as the test setup design lead for the 777-9X Full Airframe Fatigue Test at the Airframe Laboratory in Everett, Washington. Other responsibilities include: process subject expert for BT&E; part time instructor for the BCA Structures University; committee member of the SAE International G-28 Simulants Committee; and Boeing Designated Expert for structural test methodologies development.

## **4. Design Rational**

ROV Daedalus was designed to be compact, robust, powerful, and safe. As this is the 52nd ROV designed by Sea-Tech, our club has a vast pool of technical knowledge. The team used these experiences and MATE requirements to design ROV Daedalus. The ROV was built around two central pressure vessels containing necessary power supplies, and electronics. Connected by a water-jetted seaboard frame are four powerful thrusters and a tilt plate with an electrically powered

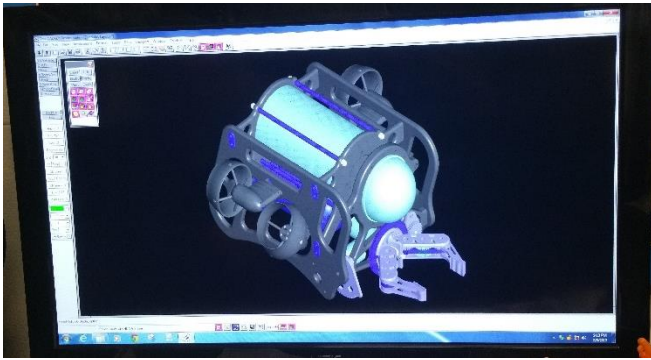


Figure 1: Working on CAD  
Photo Credits: Priya Kumar

multi-actuated claw and two cameras. See Figure 1. ROV Daedalus was designed to complete the tasks in the MATE Explorer Manual as well as meet the size and weight limitations put in place by the MATE organization. The ROV is 49.5 cm wide x 30.5 cm tall x 68.6 cm long and 12.7 kg. To ensure a safe and durable ROV, each instrument is secured within the frame and safety measures are implemented and practiced throughout the team.

## 4.1 Frame and Buoyancy

The majority of the frame is made of water-jetted seaboard, a composite with qualities similar to Delrin. See Figure 2. It has a high strength-to-weight ratio, is light compared to aluminum, and is weather-proof without any need for secondary coatings or treatment. The frame is made up of two side panels 27.9 cm in height by 45.7 cm in length connected by two center bulkhead plates. The bulkhead plates enclose the electronics vessel between them, holding it in place and strengthening its ends. The aluminum power vessel is welded to water-jetted aluminum wings and bolted to the bottom of bulkhead plates, strengthening the frame. Daedalus also has a front tilt plate to which the claw and camera assemblies are mounted.



Figure 2: Assembling the Frame  
Photo Credits: Priya Kumar

ROV Daedalus is designed to be neutrally buoyant without the need

For a large float, this is achieved by using the combined volume of the three main pressure housings, power, control and camera, as well as two additional acrylic housings on either side of the control housing designed to allow for future expansion of mission tools. To create a steady righting moment, the heavier power vessel is placed on the bottom-middle of the ROV.

## 4.2 Propulsion System

Since the founding of the Sea-Tech 4-H club, many thruster technologies have been tried, including modified bilge pumps, trolling motors, custom designed thrusters, Blue Robotics, SeaBotix, and VideoRay thrusters. This year the goal was to use a thruster that was compact, and lightweight without sacrificing thrust, reliability and durability. Based on this experience and knowledge of an array of thrusters and with MATE power and safety requirements VideoRay M5 thrusters were intended to be used. Through the progression of the design and fabrication of ROV Daedalus, it was found that the M5's would be too expensive and complicated to implement within the time allotted. The plan was modified to use Blue Robotics T200 thrusters, due to their durability, small size, power output, and overall reliability. The design accommodates the possibility of switching them out for the VideoRay M5's in the future. To accomplish this, the frame has been designed to mount the

M5 thrusters and utilize brackets for the Blue Robotics thrusters that slot into the mounts for the M5 thrusters. See Figure 3.



Figure 3: Thrusters  
Photo Credits: Priya Kumar

The Blue Robotics thrusters require 15vdc. Thus two Vicor 48 to 15vdc converters were used. The T200 thrusters have a brushless motor design and retain more torque while still being very compact and reliable. The T200 thrusters produce over 5 kg of thrust at 22 amps per thruster. However, when this average is multiplied to include all four thrusters, the power draw would exceed MATE power restrictions. The amperage has thus been limited with a programmable control system. This creates an ROV with the power necessary to accomplish a task and the ability to adjust power consumption for use under many other outside conditions.

## 4.3 Mechanical System

ROV Daedalus' mechanical system includes the claw and a tilt capability of the tilt plate. This year the ROV is equipped with a 4th Generation Sea-Tech Legacy claw, a design adaption from prior models. The 21 individual pieces of the claw assembly were printed with PLA (polylactic acid) parts modeled from water jetted aluminum parts. These changes produce an assembly that is lighter and has the advantage of being buoyant and easy to produce. Other improvements include a transparent pressure vessel for the gear-motors and clear silicone encapsulating compounds so that the electronic components inside can be visually monitored. See Figure 4.

The forward assembly provides three primary actuations: the pincer action, axial rotation, and a 90 degree vertical tilt. The pincer action is driven by a single track gear, tandem worm gear set. The

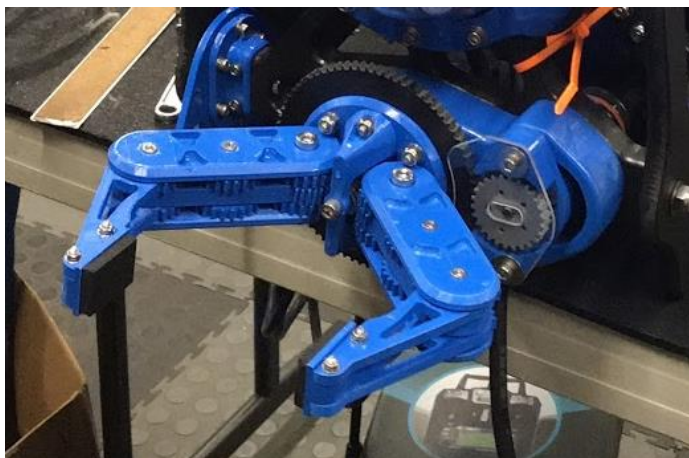


Figure 4: Claw  
Photo Credits: Gunnar Hoglund

worm is rotated by a 100:1 reduction planetary gear motor powered by 24VDC, resulting in a no-load speed of 74 RPM. The claw tips remain parallel from a full 16.5 cm open to fully closed, creating a constant force mechanism via a set of spur gears between the stationary base gear set and the gear profile on the claw tips. The claw tips are lined with a silicon rubber tape to enhance grip and soften the closed position stop. The limits of travel are controlled by a torque limiting feature. The gear motor power plug connection to the control box is a 2-pin micro-series SubConn connector. The three functions are controlled through a second RC control box.

## 4.4 Video System

ROV Daedalus utilizes three cameras. The two primary cameras are mounted on the tilt plate enclosed in a 12.7-cm-diameter compass optical acrylic dome with an integral o-ring gland. Surrounding the dome is a 3D-printed PLA shade which mounts and seals the dome in place. The shade provides the camera shielding from two stainless steel body, 3 watt, 11 mm high intensity flush mount LED bolts which improve visibility in low light and poor visibility. One of the primary cameras is perpendicular to the tilt plate to provide a wide field of vision, and the other is at a 35 degree angle to monitor the claw. This allows for greater ease when operating the claw and performing tasks that require precision or visual identification. The two primary cameras are Sony wide angle HD cameras. See Figure 5. The third camera is mounted on the bulkhead of the main pressure vessel. The camera faces backwards towards the tether to give the pilots a visual cue if the tether gets caught on an obstacle. The auxiliary camera is an automotive grade wide angle camera.

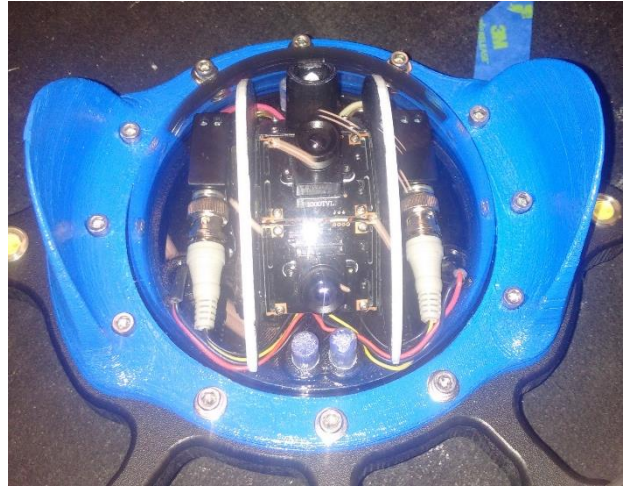


Figure 5: Main Camera Assembly  
Photo Credits: Priya Kumar

## 4.5 Shore-side Controls



Figure 6: Shore-side Controls  
Photo Credits: Priya Kumar

The Daedalus control system utilizes RC (radio control), it is designed to be simple and reliable. This is the same system used to control drones and professional quadcopters. It is made up of two separate RC systems one designated for the thrusters and the other controls the claw and Raman laser. See Figure 6.

At pool side each RC system consists of a RC transmitter with an antenna extension down the tether. This allows for the RC signal to pass through the water and to the ROV. At pool side the tether terminates at a small junction box that houses connectors for power, video output, and controls. The junction box also includes the emergency shut-off switch. 48 VDC power is

supplied through an Anderson 100 Amp positive locking connector plug. A marine grade power switch rated for 48 Volts controls the power going down the tether, allowing for quick power shut off.



## 4.6 Ship-side Controls

The onboard control system consists of two RC receivers and eight ESCs (electronic speed controllers). The receivers accept signals sent down the tether by the RC transmitters. RC signals are converted to PWM (pulse width modulation) and then are relayed to the ESCs. The ESCs modulate the power to the thrusters and claw motors based on the PWM signals from the receivers. See Figures 7 and 8.

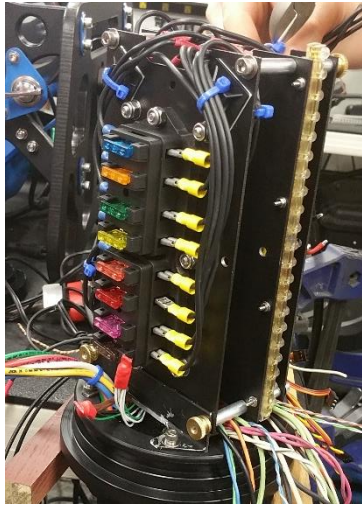


Figure 8: Control Vessel  
Photo Credits: Priya Kumar

The tether consists of an Outland Technology #C-3400 neutrally buoyant tether. This tether consists of a Cat5e and twelve 22-gauge power wires. The twisted pairs in the Cat5e set are used for the cameras while the twelve 22-gauge wires are split into two groups which handle the main 48-volts to the ROV from the control station. In addition to this, there are also two rg174 coaxial cables which provide the antenna extensions for the two RC controllers.

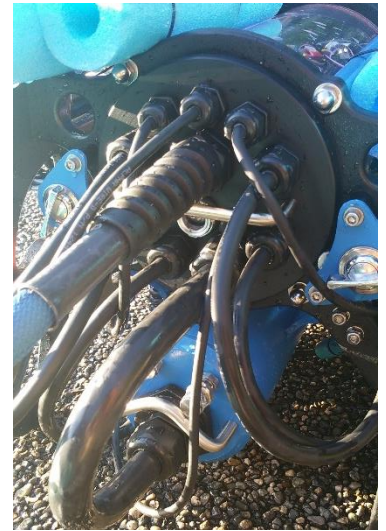


Figure 7: Pressure Vessels  
Photo Credits: Priya Kumar

## 4.7 Mission Tools

Upon receiving this year's competition manual, the team quickly realized that much of this year's competition had a large focus on physical manipulation, rather than relying on sensory data collection (though some facets of the mission concentrate on this). Thus, the team worked hard to produce tooling that would accomplish each task in the most efficient manner possible.

### 4.7.1 Claw

The claw is used to complete the majority of the detailed tasks provided by MATE. The forward assembly provides three actuations including: the pincer action to grip tools and parts; axial rotation of the claw assembly to turn valves and reposition tools; and a vertical tilt movement for reaching down to pick up objects off of the ocean floor.

### 4.7.2 Agar Collection Device

Our agar collection device relies on simple actions in order to make the agar collection process easy for the pilot to accomplish. The team brainstormed many different ideas, some involving powered motors or barbs that could hold onto the sample, or making a device with many small collection tubes to increase overall surface area and friction. The team conducted an efficiency study of the proposed devices, and selected a simple solution involving a tube and a single wire<sup>9</sup>

coupled with a check valve. The device we produced is composed of a piece of aluminum pipe 5 cm in diameter and 20 cm long. We then run a length of wire across the face of the tool. Having a claw with a near 360 degree rotation, we can use the wire to slice off the base of the agar sample, eradicating any adhesive resistance we might encounter on the bottom of the cup. After numerous tests demonstrated evidence that using this device with only these components was insufficient, the team added a cap with a check valve on one end of it. This allows water to pass through as the tool is being plunged into the sample, and grips the sample with suction as the tool is retracted. The team is confident that the tool developed will perform the task swiftly and effectively. See Figure 9.



Figure 9: Agar Collection Device Prototype  
Photo Credits: Isaiah Houghton

### 4.7.3 Bluetooth Receiver Sensor

The Bluetooth module located at the front of ROV Daedalus in a 3D printed PLA housing and provides the means to complete Task 4. We use a SKU106872 Bluetooth module, using AT (attention) commands to set it in the Slave configuration at a 9600 baud (bits per second) rate. The Slave Bluetooth module receives the serial transmission sent from the Master module and sends it to an Arduino Mini Pro, which converts it into RS-485 serial communication, then porting it to a connected SparkFun RS-485 Transceiver Breakout board. We use RS-485 protocol

because it allows us to send serial messages over a longer range since there are RS-485 transceiver boards on either end. Once the converted serial message travels our 19.2 meters of tether through a twisted pair, it is then converted by another transceiver board, which in turn sends the original serial message to an Arduino Uno at the surface. This Arduino then displays the message onto a connected LCD (Liquid Crystal Display). See Figure 10.

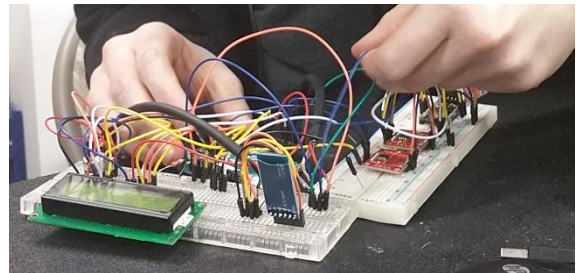


Figure 10: Bluetooth Testing  
Photo Credits: Priya Kumar



Figure 11: Raman Laser  
Photo Credits: Priya Kumar

### 4.7.4 Raman Laser

Our simulated Raman laser is produced using a long-socketed high intensity red LED which is mounted within a custom 3D printed housing. This assembly is then placed within the camera dome, allowing us to focus on, and activate the mission critical light sensor with ease. This feature is controlled by the claw manipulator remote on the poolside. See Figure 11.

## 4.7.5 Valve Rotation Device

The valve rotation device is a mission tool designed to assist with the rotation of the valve. The tool is a foam lined cone that goes in the claw and allows the pilot to simply drive the ROV up to the valve and begin the rotation, rather than having to attempt to align and the claw on the valve. The cone fits around the valve and can keep hold of it by having the ROV continuing to drive forward towards the valve.

# 5. ROVs and Port Cities of the Future<sup>1</sup>

This year's mission is a simulated RFP (Request for Proposals) sent from the Port of Long Beach in need of a machine that is able to complete maintenance and data collection tasks. This mission is broken down into four primary submissions, titled Commerce, Entertainment, Health, and Safety. Each is designed to show a particular aspect of what goes on in the sometimes precarious environment and conditions that arise with routine maintenance of a port city.



Figure 12: Hyperloop Drawing  
Photo Credits: 2017 MATE Explorer Manual<sup>1</sup>

### Task 1: Commerce: Hyperloop Construction

This task simulates construction of an underwater Hyperloop, an incredibly innovative vacuum tube transportation system which, if completed, would allow transportation of goods, cargo, and even people, much faster than by conventional methods. The increased speed of transport would increase economical value and efficiency in transportation of goods and other cargo. See Figure 12.

### Task 2: Entertainment: Light and Water show maintenance

Centers on maintenance of Long Beach's amazing light and water fountain show. The task consists of diverting the flow of water, removing old fountains, and reinstalling new ones so the show may continue running successfully. See Figure 13.

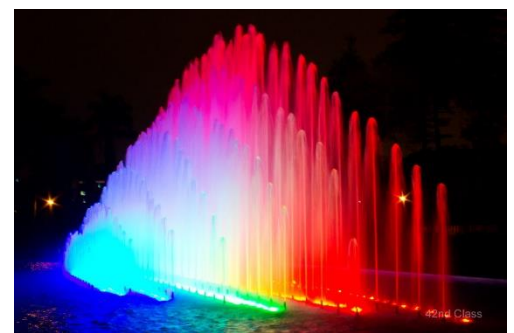


Figure 13: Water Show  
Photo Credits: 2017 MATE Explorer Manual<sup>1</sup>

### Task 3: Health: Environmental Cleanup

This task requires the ROV to simulate diving to the bottom of the ocean and using a simulated Raman laser to test the contaminated sediments on the ocean floor, a problem caused by excessive use of the bay when receiving and shipping cargo. Having used the laser to identify a contaminated area, the team will then collect a sediment sample using a collection device provided by the company and retrieve a series of clams from contaminated area for observation and testing. Once this has been done, the company is tasked with capping the contaminated area to prevent hazard to the surrounding environment.

#### Task 4: Safety: Risk Mitigation

This task involves the company using their ROV to inspect the contents of an accident site, in which a cargo ship dropped multiple cargo containers into the surrounding waters. The company is tasked to identify the containers, determine their contents and evaluate the threat level of each container then mark the most hazardous container with a buoy. Finally the company must produce a map of the containers, indicating the identified threat level of each container.

## 6. Safety

ROV Daedalus has been designed to comply with safety guidelines specified in the MATE manual. All on board systems are protected by properly sized fuses and an emergency power switch which disconnects the 48VDC power in the unlikely event it is needed. On the machine itself, all moving parts are labeled to prevent a pinch or contact injury. All gear pinch points are shrouded with lexan covers, all thrusters are shrouded and the entire ROV was designed to have smooth, rounded edges. In addition to this, safety glasses are worn when eye safety (See Figure 14) is a concern, hair is secured back, and all loose clothing items are removed when working on and around the machine. Finally, a safety checklist is used when setting up and operating the ROV.



Figure 14: Gunnar Using the Lathe  
Photo Credits: Priya Kumar

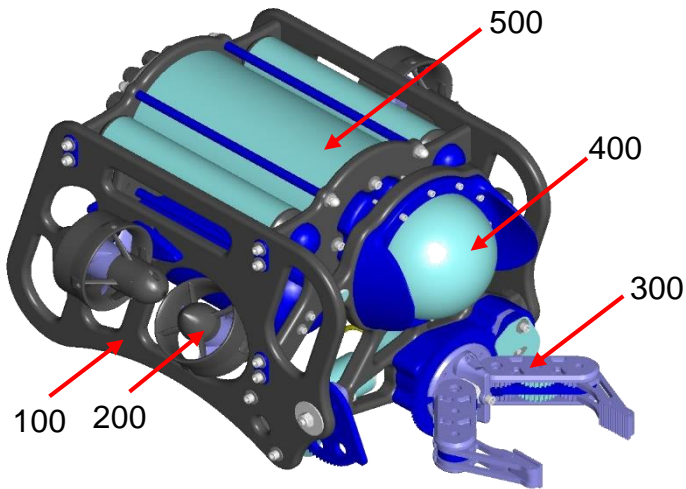
## 7. Project Management



Figure 15: Priya Working on Documentation  
Photo Credits: Lee McNeil

To ensure productivity in the limited time the team had to complete the ROV, a task assignment list was continually maintained and updated. Having a constant source to check for assignments was essential in the beginning procedures of designing and eventually assembling the ROV. Defining specific team roles and responsibilities assisted in maintaining a group effort in every task completed. Subject matter experts (SME's) allowed all members to properly understand the inner workings of the machine. These SME's and company roles were assigned before the fabrication of the ROV, allowing each member to do any necessary research or design beforehand. The distribution of roles was decided by each team member's experience or interest level. See Figure 15.

# 8. Expenditure Summary



600 Tether

700 Shore-Side Controls

### Total Value

2017 ROV Build Expenses	\$4,920.00
2017 Estimated Travel Expenses	\$5,160.00
2017 Total Expenses	\$10,080.00
Donation Value	(\$1,945.00)
Repurposed Value	(\$0.00)
<b>2017 Net Expenses</b>	<b>\$8,135.00</b>

### ROV Build Expenses

100 Frame & Buoyancy .....
200 Propulsion System .....
300 Mechanical System .....
400 Video & Sensors .....
500 Ship-side Control System .....
600 Tether .....
700 Shore-side Controls .....

**ROV Build Value**

	<b>Purchased</b>	<b>Donated</b>	<b>Repurposed</b>	<b>Total</b>
100 Frame & Buoyancy .....	\$175.00	\$600.00	\$0.00	\$775.00
200 Propulsion System .....	\$950.00	\$0.00	\$0.00	\$950.00
300 Mechanical System .....	\$425.00	\$400.00	\$0.00	\$825.00
400 Video & Sensors .....	\$660.00	\$0.00	\$0.00	\$660.00
500 Ship-side Control System .....	\$530.00	\$600.00	\$0.00	\$1,130.00
600 Tether .....	\$0.00	\$240.00	\$0.00	\$240.00
700 Shore-side Controls .....	\$235.00	\$105.00	\$0.00	\$340.00
<b>ROV Build Value</b>	<b>\$2,975.00</b>	<b>\$1,945.00</b>	<b>\$0.00</b>	<b>\$4,920.00</b>

### Estimated Travel Expenses

A Travel to and from Long Beach ...
B Accommodations .....
C Meals .....

**Estimated Travel Value**

	<b>Purchased</b>	<b>Donated</b>	<b>Repurposed</b>	<b>Total</b>
A Travel to and from Long Beach ...	\$950.00	\$0.00	\$0.00	\$950.00
B Accommodations .....	\$2,670.00	\$0.00	\$0.00	\$2,670.00
C Meals .....	\$1,540.00	\$0.00	\$0.00	\$1,540.00
<b>Estimated Travel Value</b>	<b>\$5,160.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$5,160.00</b>

# 9. Testing and Troubleshooting



Figure 16: Camera Water Test  
Photo Credits: Gunnar Hoglund

ROV Daedalus has gone through extensive testing both in and out of the pool. Each sub-assembly (i.e. camera assembly, claw assembly, thruster systems, etc.) isolated and ran before the ROV was tested as a whole. See Figure 16. Testing the ROV as a whole, included each sub-system to be integrated into the master assembly, and then tested by powering on the ROV. After ensuring that the power and current consumption was at the correct level, each of the motors were tested, making sure that their configuration was correct. The cameras were then powered on and degrees of motion used by our claw were tested. ROV Daedalus was then placed in the water to look for signs of leakage and calculate buoyancy. The ROV was then piloted through basic maneuvers before finally being pulled out and checked for malfunction and water penetration. See Figure 17.

If a problem was identified with an ROV system, steps were taken to perform additional testing to isolate the problem.

When the problem was identified, possible solutions were proposed. A troubleshooting session would take place to determine possible solutions and if necessary more tests were performed to better determine the nature of the problem(s) under the consideration of the solutions. The proposed solutions were then tested in a controlled environment, starting with the simplest and most likely to succeed. If no solution was found or a new problem arose more brainstorming and testing was done to improve the designs using the information gathered.

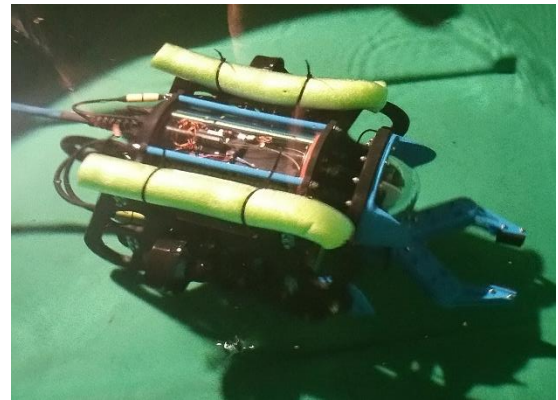


Figure 17: ROV Water Test  
Photo Credits: Priya Kumar

# 10. Critical Analysis - Challenges

## 10.1 Non-Technical Challenges

One of biggest issues we encountered this year was time management. At the beginning of the year we intended to reuse the ROV we had competed with the year before, as it was powerful, robust and open to upgrades. But when we learned that MATE had implemented a size and weight restriction we had to pivot to a brand new machine and design. To accomplish this, a step-by-step milestone plan was laid out to design and produce a machine with adequate time for pool practice at an early stage. Though the first two milestones were completed: laying out a general design and a list of specific features the ROV needed and then designing it in detail with CAD software. We struggled to complete the final steps according to our time goals. This in turn resulted in us pushing back our

drive and practice time to a much later date than we would have liked. To remedy this problem, we planned extra meetings to make up the lost time and produced bullet lists in order to be more systematic and efficient with our remaining time.

## 10.2 Technical Challenges

Other problems occurred with the actual design of the ROV. These included physical interference which had not previously been identified in the CAD model and ordering improper components thought to be needed. There were several events in which ordering parts, specifically cables, were not communicated effectively, resulting in us getting components that could not be used on the ROV. Secondly, there was interference between the swivel motor gear and the front pivot plate which we hadn't foreseen. See Figure 18. This problem was solved by 3D printing a claw base that extended it forward. However, this solution caused the claw tips to be out of view of the assigned camera. To cope with this issue, we decided to mount a mirror to allow us to visualize the tip of the manipulator while still seeing directly ahead for main navigation. We also discovered unstable organization with some of the components inside of our electronics vessel. These issues were remedied with new cables, better suited to the application. The gear motor interference was remedied by machining down the portion of the gear that was causing the problem.

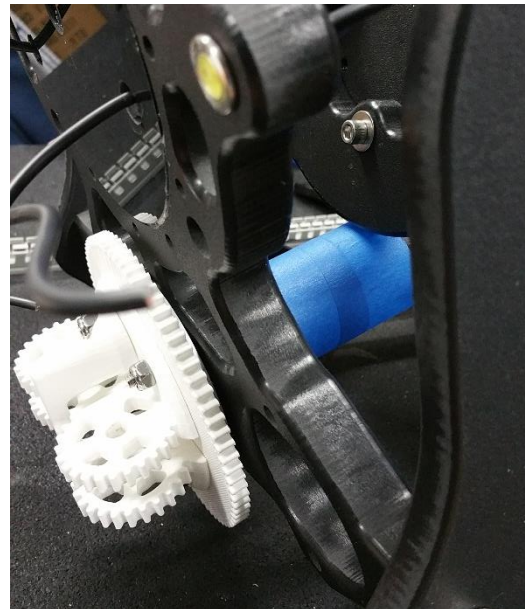


Figure 18: Claw Collision  
Photo Credits: Priya Kumar

## 11. Future Improvements

In the future, we firmly believe that starting the ROV design and build process earlier in the year would be much more beneficial to our company. It would result in less strain on everyone as a whole. In tandem with this, a stronger plan for milestone management could be implemented into our processes, allowing us to complete each assembly on time and offer us ample time to test each one. Our company also believes that rudimentary training and observation of CAD and CAD design could immensely benefit future company members to understand some of the more complex assemblies. This would also offer more eyes to catch some inconsistencies in the model that members who have worked on it regularly might not be as likely to see.

In upcoming seasons we plan to upgrade and continue to improve upon ROV Daedalus. The only specific plan for this that we have at this time is to upgrade the thrusters from the Blue Robotics T200 thrusters to the VideoRay M5 thrusters. This upgrade would allow greater efficiency, power, and reliability.

## 12. Reflections

Despite the challenges we faced, working as a team this past year has been a great experience. The team worked together in a manner that was very conducive to productivity. The design and build process was intensive and sometimes a little chaotic, but it was also a lot of fun. Each of us had the opportunity to work in an area that we weren't quite comfortable or experienced with. Working in these different areas has allowed us to learn a lot of great skills, be it mechanical, cooperative, or different problem solving methods. Regardless of the specific information obtained, the problem solving and teamwork skills we have learned are invaluable. We look forward to applying our new skills in future academics, occupations, and life in general.

## 13. Inspiration

The inspiration for our team name and logo came from the Greek character Daedalus. Daedalus was a skilled craftsman, artist, and inventor. He is credited in Greek mythology with creating the Labyrinth, but more notably the feathered wings that he and his son used to try and escape the island of Crete. His elegant designs and innovation are things we strive for in our own technological pursuits. Our logo represents the Labyrinth inside the wings and with water below. See Figure 19.



Figure 19: Daedalus  
Photo Credits: Britannica<sup>2</sup>



# 14. Acknowledgements

We would like to thank the following for their support:

Lee and Shannon McNeil  
Yoko and Sundeep Kumar  
Rick and Cindy Ristow  
Eiji Haratani  
Jay Cocheba  
James Harvey  
Nicholas Orndorff  
Jack Williams  
Previous Members  
Our families  
Microsoft  
SolidWorks



**MATE**  
MARINE  
ADVANCED  
TECHNOLOGY  
EDUCATION  
CENTER



# 15. References

<sup>1</sup>2017 MATE Explorer Manual

[https://www.marinetech.org/files/marine/files/ROV%20Competition/2017%20competition/Missions/Revised%20documents/2017%20EXPLORER%20Manual%20FINAL\\_3\\_29\\_2017\\_cover.pdf](https://www.marinetech.org/files/marine/files/ROV%20Competition/2017%20competition/Missions/Revised%20documents/2017%20EXPLORER%20Manual%20FINAL_3_29_2017_cover.pdf)

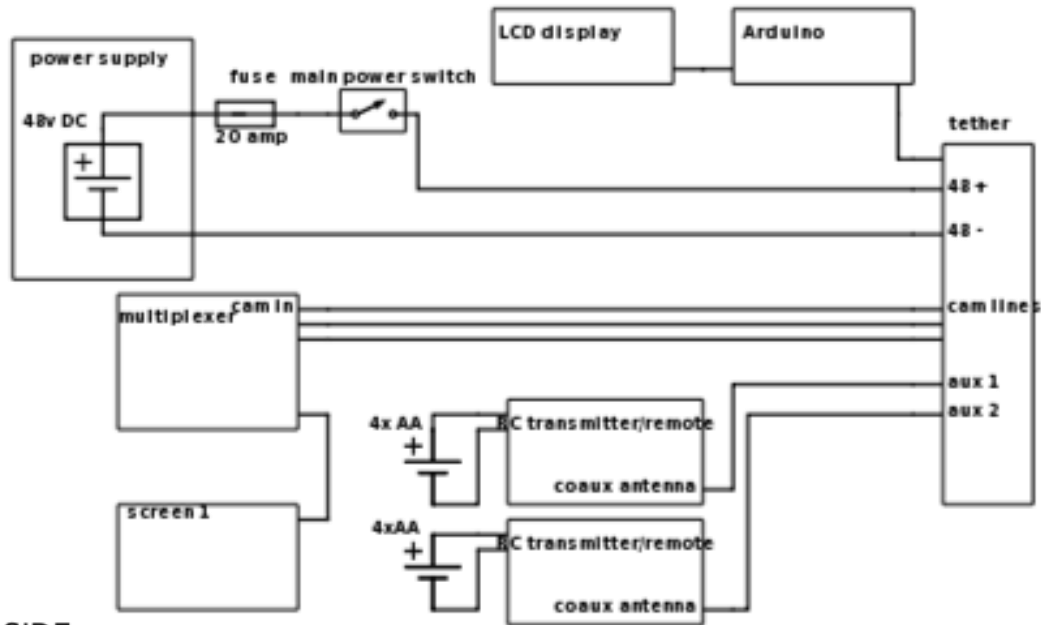
<sup>2</sup>Britanica

<https://www.britannica.com/topic/Daedalus-Greek-mythology>

# 16. Appendix

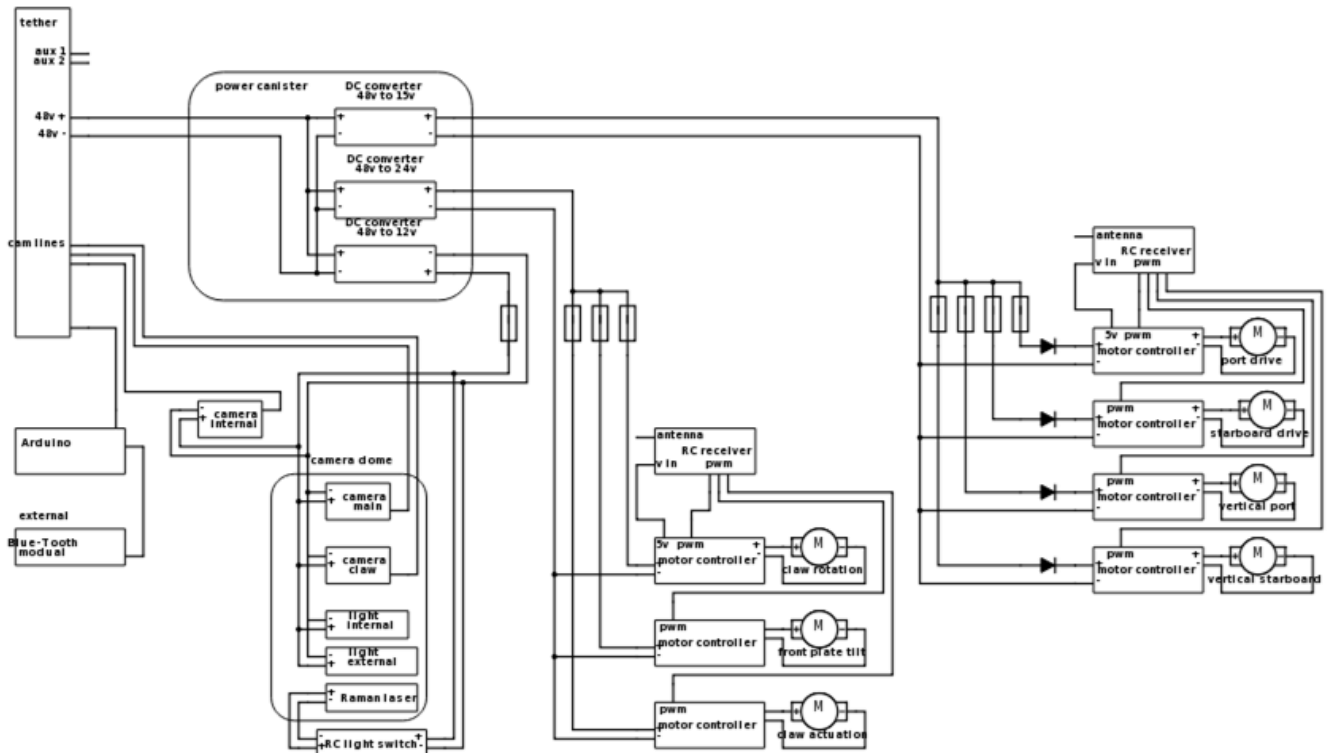
## Appendix A: SID

### Daedalus Electronics SID



POOL SIDE

ON-BOARD



# Appendix B: Safety Check List

## 1. Poolside station supplies

- Monitor w/ power supply
- Multiplexer w/ power supply
- Interconnection cable
- RC remote (A & B)
- ROV
- DC power cable

## 2. Setup poolside station

- Connect AC power to monitor and multiplexer
- Connect RC remotes to junction box
- Connect multiplexer to junction box
- Connect multiplexer to monitor
- Check if power supply is wired properly
- Connect anderson power connector to tether junction box

## 3. Power on ROV

## 4 .Tear Down poolside station

- Power off ROV
- Disconnect anderson power connector
- Disconnect multiplexor
- Disconnect RC remotes
- Disconnect AC remotes

# Appendix C: ROV CAD Images

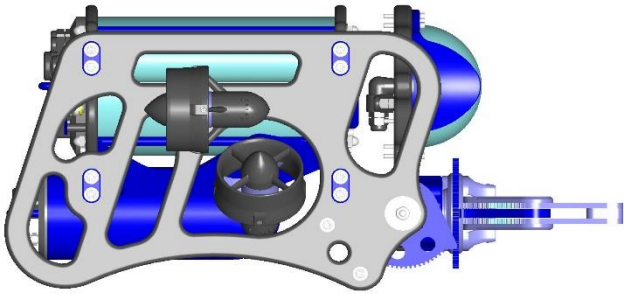


Figure 20: CAD Image 1

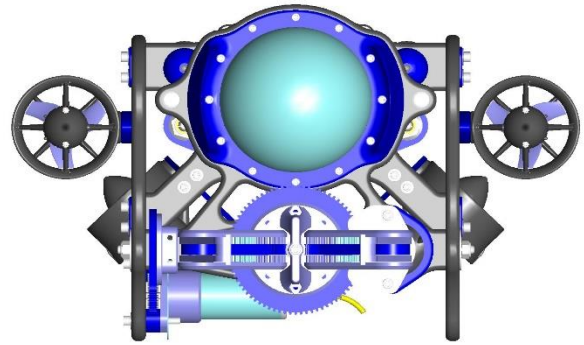


Figure 21: CAD Image 2

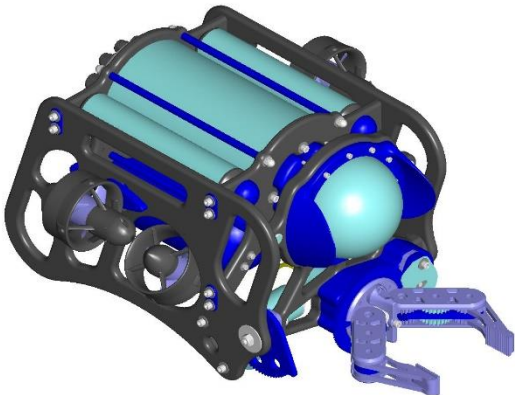


Figure 22: CAD Image 3

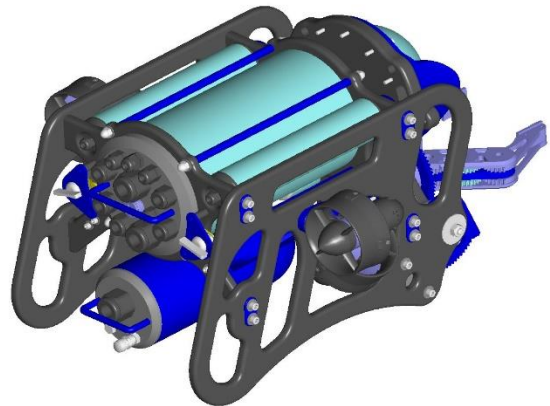


Figure 23: CAD Image 4

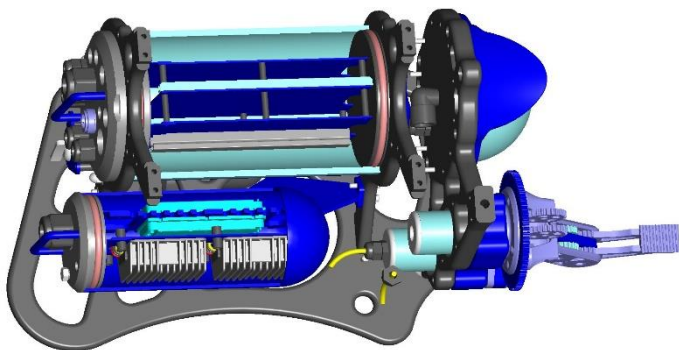


Figure 24: CAD Image 5

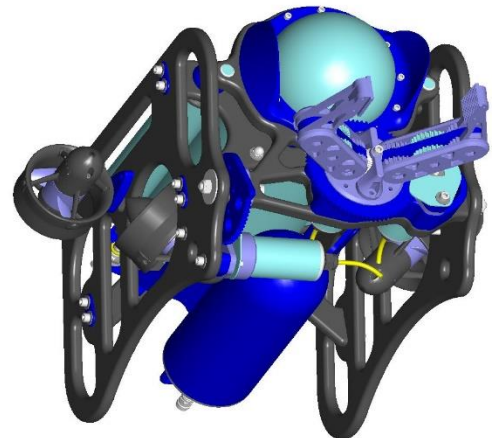


Figure 25: CAD Image 6

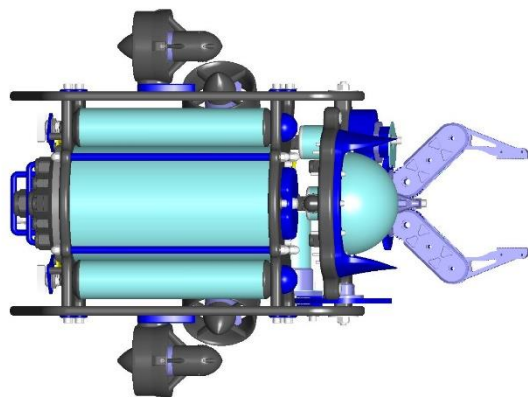


Figure 26: CAD Image 7

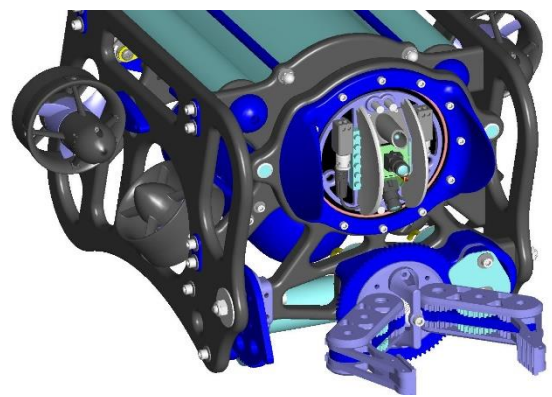


Figure 27: CAD Image 8