Daedalus II

Sea-Tech 4-H Club Located in Mt. Vernon, WA, USA
150 km from Federal Way, WA, USA

PRIYA KUMAR
- Chief Executive Officer
- Mechanical & Video Systems Specialist
- Mission Commander

ISAIAH HOUGHTON
- Chief Operating Officer
- Mission Tools Specialist
- Data Analyst

LAZLO COCHEBA
- Chief Financial Officer
- Propulsion System Specialist
- Tether Manager

COOPER RISTOW
- Director of Research and Development
- Control Systems Specialist
- Pilot/Manipulator Operator

SATONE HARATANI
- Marketing and Communications Director
- Structural Systems Specialist
- Tether Manager

SPENCER COCHEBA
- Environment, Health, and Safety Director
- Power Systems
- Pilot/Manipulator Operator

MENTORS:
- Jay Cocheba
- Ric Ristow

1. ABSTRACT

Daedalus II from Sea-Tech 4-H Club consists of three high schoolers, two running start students and one undergraduate student. Each has between four and eight years of experience designing and producing remotely operated vehicles (ROVs). The company strives to implement and understand new technologies to develop reliable and efficient products for use in demanding marine environments. As a product of the company's 31 years of accumulated experience, knowledge, and skills, Daedalus II is one of Sea-Tech's most advanced ROVs.

This year's ROV incorporates new technology and materials to fulfill the needs of the University of Washington's (UW) Applied Physics Laboratory's (APL) Request for Proposals (RFP) for an ROV capable of completing a variety of tasks throughout the Puget Sound. Daedalus II meets the size and weight criteria; is capable of operating in salt and freshwater; and is compact and agile, while still prioritizing effectiveness and safety. Daedalus II is equipped with tooling to search for and recover Boeing aircraft engines, deploy an ocean bottom seismometer (OBS) to monitor the earth's movements, and install tidal turbines.

The following pages in this technical document will describe the management; safety; research and analysis; modeling and manufacturing; careful testing; and reflections of Daedalus II.

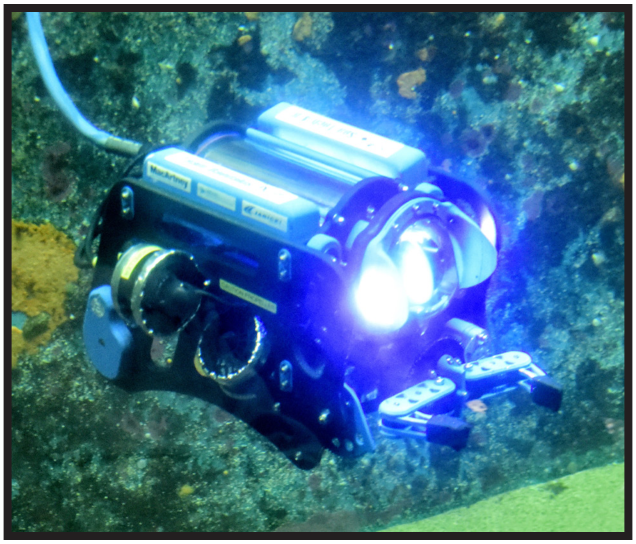

Figure 1: ROV Daedalus II in the Seattle Aquarium WOWW Tank

Figure 2: Company Photo (left to right: Priya Kumar, Isaiah Houghton, Lazlo Cocheba, Cooper Ristow, Satone Haratani, Spencer Cocheba)

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2. DESIGN RATIONALE

ROV Daedalus II is engineered to be compact, robust, and safe. As the 54th ROV designed by Sea-Tech, the club has a knowledge base spanning 18 years. The team used these experiences and the MATE specifications, such as size and weight, to guide the design of ROV Daedalus II. The ROV's components were built around two central pressure vessels containing power supplies and electronics. Mounted to a water-jetted high-density polyethylene (HDPE) frame are four ducted thrusters and a forward rotating tilt plate supporting an electrically powered multi-actuated manipulator and three cameras. ROV Daedalus II was designed to complete the tasks in the MATE Explorer Manual. The ROV is 49.5 cm x 30.5 cm x 68.6 cm and weighs 12.8 kg. Safety measures are implemented in the ROV design and each instrument is secured within the frame.

2.1 DESIGN EVOLUTIONS

ROV Daedalus II evolved through planning, modeling, prototyping, testing, and modifying. Over its development, several different design modifications were implemented. The planning process began by listing key design criteria and researching components and materials. Hand-drawn sketches of the ROV structure evolved into 3D CAD models and individual, detailed components were added to test the integration of the ROV.

The initial model incorporated five VideoRay M5 thrusters due to power specifications. After a cost and capacity analysis, Blue Robotics T200 thrusters replaced these. A discovery of the sway thruster's interference in the CAD model resulted in removal of the thruster and angled positioning for lateral maneuvers. Brainstorming sessions were held to develop multipurpose designs. For example, clear canisters allow the company to visually monitor components while being aesthetically pleasing. The holes in the frame improve water dynamics while doubling as handles.

ROV components were prototyped to visualize and test functionality. The most extensive prototyping was conducted with the claw material. Strength and flexibility of polylactic acid (PLA), nylon, and aluminum part combinations were prototyped and tested. Dry and wet efficiency tests were conducted at component, assembly, and system levels.

Daedalus II sub-system modifications improved the functionality and reliability of the system as a whole. Camera clarity, sealant methods, gear motor speed, and control variability were a few areas upgraded this build season. Decisions on the original design and upgrades were made after consideration of research on functionality, cost, and implementation time. Components were first ranked by the most pressing criteria, before being discussed and voted upon.

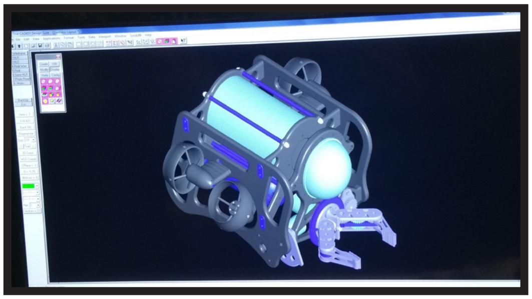


Figure 3: CAD Model in Progress

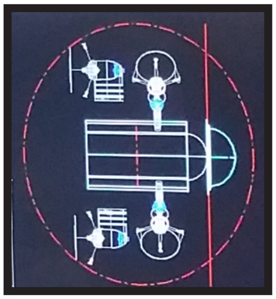


Figure 4: ROV Size Check Top View

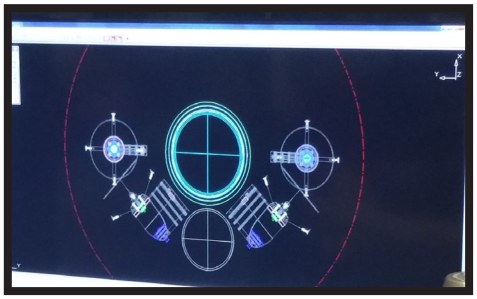


Figure 5: ROV Size Check Front View

2.2 FRAME AND BUOYANCY

The frame is made of water-jetted polyethylene plate called King StarBoard HDPE, a durable and robust plastic, designed to protect the delicate components within. StarBoard HDPE is fracture resistant, easily machinable with standard equipment and weather-proof without any treatments; an improvement from previously used

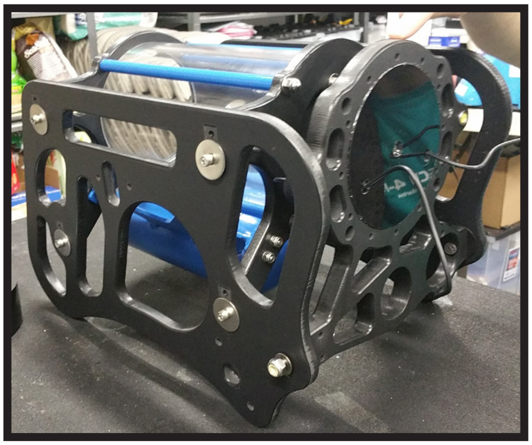


Figure 6: ROV Frame Assembly

aluminum. The frame is comprised of five custom machined panels. Two side panels 27.9 cm in height by 45.7 cm in length by 1.2 cm thick connected by two center bulkhead plates. The bulkhead plates enclose the electronics vessel, 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. A StarBoard HDPE front tilt plate mounts the manipulator and camera assemblies.

ROV Daedalus is designed to be neutrally buoyant, without the need for a large float, achieved by using the combined volume of the three main pressure housings, power, control, and camera. Two 24 cm by 7 cm by 5 cm floats made from 3.6 kg per cubic foot polyurethane closed cell foam complement the vessel flotation. A strong righting moment is created by the placement of the heavier power vessel on the bottom-middle of the ROV.

2.3 PROPULSION

Since the founding of the Sea-Tech 4-H club, many thruster technologies have been developed, including modified bilge pumps, trolling motors, and custom-designed thrusters. Sea-Tech has also used many commercially built thrusters such as Blue Robotics, SeaBotix, and VideoRay thrusters. By analyzing thruster mechanism, the company set this year's goal to integrate a compact and light thruster without sacrificing thrust, reliability, or durability. The ROV frame provides the ability to mount various thruster designs to allow for more versatility in the field.

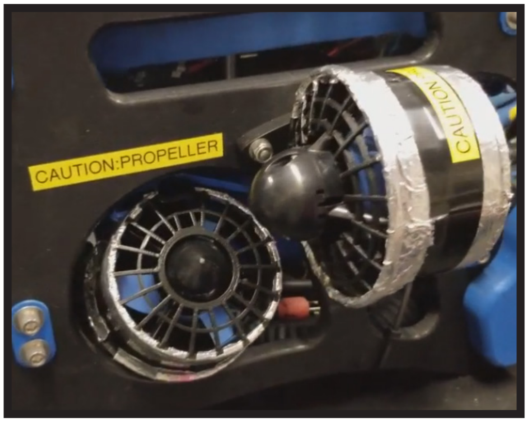


Figure 7: Thrusters w/ Additional Shrouding

Based on thruster analysis and MATE power and safety requirements, Blue Robotics T200 thrusters were selected. Two Vicor V48A15C500B 48 VDC to 15 VDC converters supply 500 watts of power to the thrusters. This translates to a total of about 65 amps at 15 volts to power the four thrusters. The brushless motors maintain more torque than brushed thrusters, while still being compact and reliable. The T200 thrusters produce over 5 kg of thrust at 22 amps per thruster. A programmable control system limits the amperage to keep the power draw within MATE power restrictions, 48 volts at 30 amps equating to 1440 watts. The ability to regulate the power consumption allows for versatility in a range of environments.

2.4 MECHANICAL SYSTEM

The ROV Daedalus II's mechanical system is composed of a mechanical manipulator with tilt and rotational capability. The ROV is equipped with a 5th Generation Sea-Tech Legacy manipulator, a design adaption from prior models. The manipulator is an assembly of ten 3D printed PLA parts and six printed Nylon parts replacing a previously water-jetted all-aluminum design. Welded aluminum base sectors were integrated to strengthen the former all-printed plastic manipulator. An alodine aluminum prep protects these parts from corrosion. This hybrid design produced lighter, more buoyant, and an easily reproduced product. Transparent acrylic pressure vessels house the gear-motors encapsulated in automotive grade urethane which establishes a visual monitoring system of the components. Two o-rings and a waterproof compression seal prevent water intrusion.

The forward, tilt plate assembly provides three primary actuations: the pincer action, axial rotation, and a 90 degree vertical tilt. The pincer action is driven by a single worm and tandem worm gear set. The worm is rotated by a 71:1 reduction planetary gear motor powered by 24VDC, resulting in a no-load speed of 74 RPM.

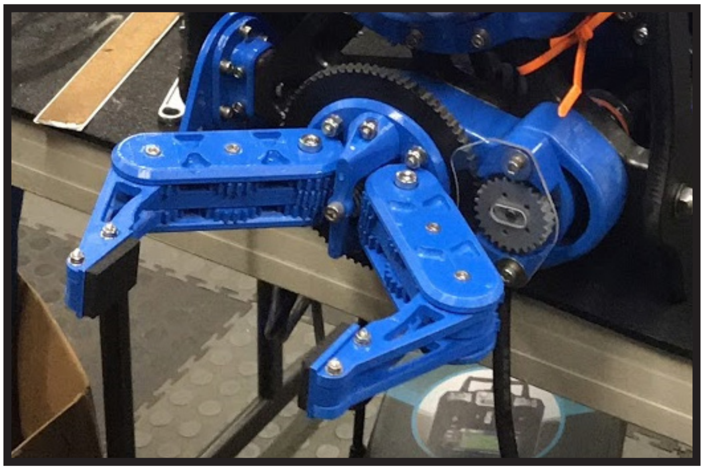


Figure 8: Mechanical System Assemby

The manipulator 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 manipulator tips. The manipulator tips are dipped in a rubberized coating to enhance grip and to soften the closed position stop for safety measures. The gear motor power connection to the control box is a 2-pin micro-series SubConn connector for its reliability and simplicity. The three functions are controlled through a second RC controller.

2.5 VIDEO SYSTEM

ROV Deadalus II has a three camera video system. The cameras are mounted on a printed PLA trapezoidal frame attached to the tilt plate and enclosed in a 12.7-cm-diameter optical acrylic dome with an integral o-ring gland. A printed PLA shade mounts and seals the dome in place. The shade protects the camera from two stainless steel body, 3 watt, 11mm high intensity flush mount LED bolts which improve visibility in the low light conditions of Lake Washington and Cascadia subduction zone.

The main camera is perpendicular to the tilt plate and provides a 145 degree field of view (FOV). The lower and upper navigation cameras are mounted at a 35 degree angle above and below the axis of the main camera to monitor the manipulator and surface respectively. The downward facing camera, or the manipulator camera, allows for greater ease of use and simplicity when operating the manipulator and performing tasks that require precision operations. The upper navigation camera allows a forward field of view when the tilt plate is in the downward position and a view above the ROV when the tilt plate is in the upright position.

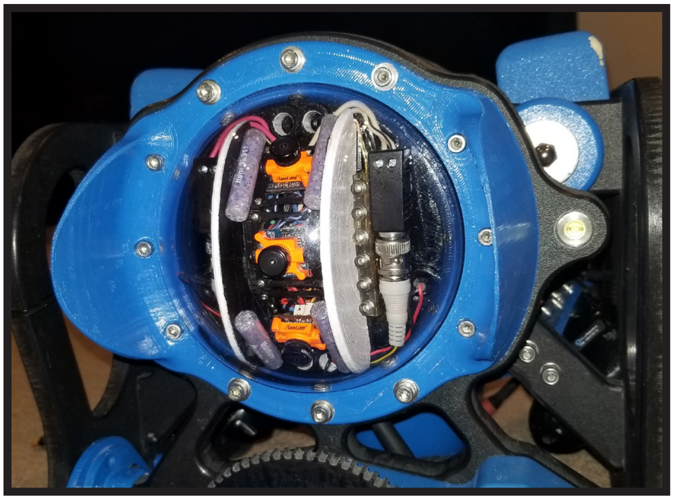


Figure 9: Camera Assembly

All three cameras are RunCam micro sparrow 700tvl 145 degree FOV cameras. The clarity of these cameras provide clear data for the implementation and use of an image recognition software to identify tail ID numbers on the aircraft of Lake Washington.

2.6 SHORE-SIDE CONTROL STATION

The Daedalus control system uses radio control (RC) for versatility, simplicity and reliability. The structure of this system allows the company to easily switch radios to a pilot's preferred control configuration. This type of system is also used to control drones and professional quadcopters, with proven reliability. The controls are made up of two separate RC systems with one being designated for the thruster controls and the other controls the mechanical system.

At pool side, the RC systems consist of two transmitters, one being FlySky Taranis QX7 for main control and the FlySky FS-6i radio for manipulator control, with an antenna extended down the tether to where it transmits inside the main pressure housing to dual receivers, one for each radio. This allows for the RC signal to pass through the water and to the ROV. At pool side the tether terminates at a 5 cm x 11 cm x 20 cm junction box that houses the main connector for power, three video output wires, two wires for controls, and a marine grade, 48 volt emergency power shut-off switch controls the power to the ROV and allows for quick power shut off. The 48 VDC power is supplied through an Anderson 100 amp positive locking connector plug.

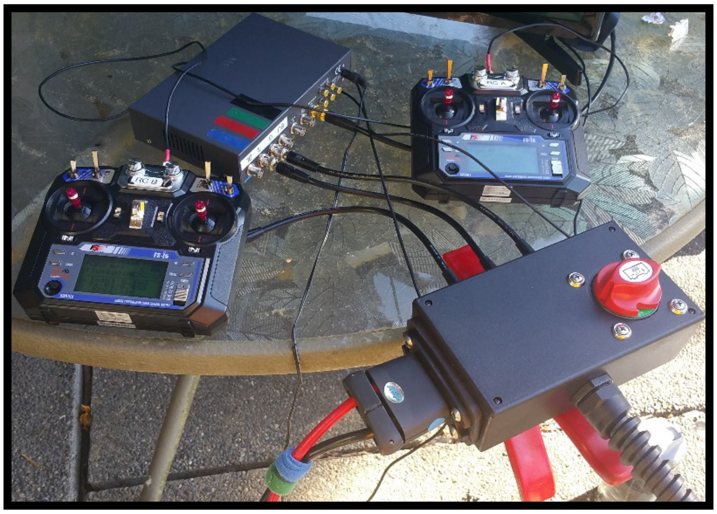


Figure 10: Top Left: Multiplexer; Top Right & Bottom: Left RC Controlers; Bottm Right: Junction Box

2.7 SHIP-SIDE CONTROLS

The tether is primarily made up of an Outland Technology #C-3400 neutrally buoyant tether consisting 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. Two rg174 coaxial cables provide the antenna extensions and a pneumatic tube. A braided polypropylene holds the tether together.

The onboard control system is housed in two cylindrical canisters. The upper, 15.24 cm diameter x 26.67 cm long transparent cast acrylic electronics vessel consists of three mounting plates attached to a cap sealed with a silicon rubber o-ring seal. Affixed to these plates are two RC receivers; the FlySky FS-iA6; eight electronic speed controllers (ESCs); a 12 VDC, 15 VDC, and 24 VDC wire buss; fuse block; and two LED light strips. The receivers accept signals sent down the tether by the RC transmitters. RC signals are converted to pulse width modulation (PWM) via the RC receiver and then are relayed to the ESCs. The ESCs modulate the power to the thrusters and manipulator motors based on the PWM signals from the receivers.

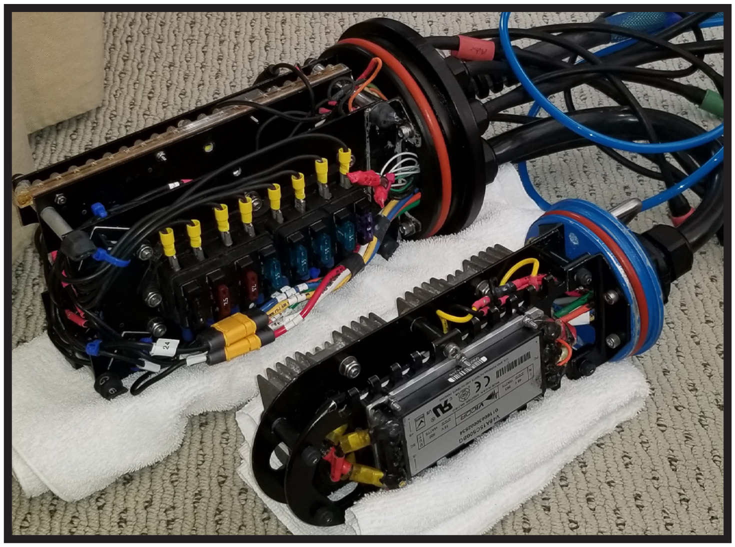


Figure 11: Upper and Lover Vessel Electronic Components

The lower, 10.2 cm diameter x 24.13 cm long powder-coated aluminum power vessel houses two Vicor power bricks, a 12 VDC and a 24 VDC marine grade waterproof DC-DC converter. This vessel connects to the electronics vessel through a eight conductor power tether. All wires that enter and exit the vessels pass through plastic waterproof compression seals. The vessels connect to components, such as the thrusters and camera, though the use of SubConn wet-mateable connectors.

2.8 MISSION TOOLS

MANIPULATOR

ROV Daedalus II's manipulator is the primary tool for the completion of mission tasks. The manipulator is used to attach the lift bag to the debris and aircraft engine. It mounts the pneumatic tube for the lift bag; holds and rotates the OBS leveling apparatus described below; installs the Intelligent Adaptable Monitoring Package (I-AMP); places the mooring and suspends the Acoustic Doppler Velocimeter (ADV).

IMAGE RECOGNITION SOFTWARE

As a result of time constraints and maximized company productivity, Daedalus II did not develop an image recognition software. However, the system is designed to easily plug a camera into an external computer, where a program can be implemented to use the camera feed to identify the aircraft located in Lake Washington.

Figure 12: PVC Lift Bag

LIFT BAG

Our company's lift bag has a lift capacity of 6 kg and is used to lift the debris and aircraft engine. The lift bag is constructed from a 33 cm long piece of 6 inch (15.24 cm) PVC tube glued to a 6 inch PVC drain cap with a variable leak valve used to control the dropping speed of the debris. An air compressor at poolside fills the lift bag though a 6.35 mm diameter HSF 95A polyurethane hose attached to the claw by a 3 cm aluminum tube. After the unit carrying debris has been safely lowered to the sea floor. It is released by the manipulator.

INDUCTIVE COUPLING

Prior to leveling the OBS, a reliable source of power must be provided. In order to do this the company built a custom designed inductive power connector. This tool is made from printed PLA parts and a polycarbonate tube, to house a 9 volt battery and 5 volt regulator. This powers the receiver module located on the OBS. To ensure the internal pressure of the canister does not increases to an unsafe level, the cap is engineered to release pressure and prevent damage or failure.

WIFI SYSTEM

The WiFi system uses an ESP8266 module to receive the information from the transmitting ESP8266 module's webpage using HTTP commands. This system collects the OBS leveling and seismograph data from the Earthquake mission. The information is sent to an on-board Arduino Pro Micro which sends the transmission to a RS-485 bridge. This bridge was produced after discussion with an industry professional advising that a two Arduino board system would result in data loss over the length of the tether. Traveling through the RS-485 bridge, the data is sent from the surface RS-485 module to a receiving Arduino, which directs the data to the Serial Monitor on a laptop. Due to a short underwater connection range, the module is mounted near the front of the ROV, enabling the easy extraction of information.

OBS LEVELING APPARATUS

In performing the OBS leveling operation, the company realized the difficulty of accurately manipulating the handles by only the manipulator. A printed PLA, 15 cm long OBS leveling apparatus allows for quicker alignment and a more secure hold while leveling the OBS. The tool is held in the manipulator and the operational end slides over a handle to rotate the peg. After the OBS is leveled correctly, the apparatus is returned to the surface and the ROV is regeared for its next mission.

AIRCRAFT SEARCH ZONE & TIDAL DATA SHEET

An Excel sheet contains the necessary equations and conversions to decipher flight data and determine the aircraft search zone. The direction, wind speed, ascent, and descent rates are inputted into the spreadsheet to determine the distance to the crash site.

Before installing the tidal turbine, the company must discern an optimum deployment location to maximize power generation using tidal data available through the DeepZoom website. The use of an Excel spreadsheet allows the company to input the raw tidal data and calculate all necessary conversions to determine the ideal location.

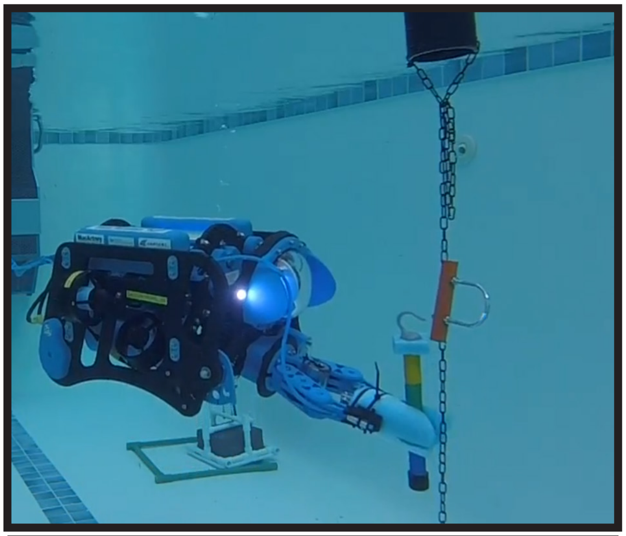


Figure 13: Daedalus II placing an ADV prototype on the mooring with the use of a multi purpose OBS leveling tool prototype

DISTANCE MEASUREMENTS

To measure the distance for placement of the mooring from the base of the tidal turbine, the ADV is placed on the pool floor and its known length described below is used as a comparative guide. A screenshot of the ROV's camera feed is taken and provided to the on-deck data analyst. The analyst measures the ADV in relation to the mooring line and turbine to determine the location for the mooring placement. Testing of this method has resulted in distance measurements within 5 cm of the actual distance.

ACOUSTIC DOPPLER VELOCIMETER

The company's 20 cm long ½ inch PVC pipe ADV is designed to be hung from the u-bolt on the mooring line by one three printed PLA hooks. A piece of rebar weighing 425 grams is glued to the bottom end of the ADV to create negatively buoyant, bottom-heavy tool. In the event that the ADV is dropped, it will stay in an upright position to allow for retrieval by the manipulator. The weight of the ADV helps keep it from detaching from the attachment point on the mooring line.

3. JET CITY: AIRCRAFT, EARTHQUAKES, AND ENERGY

To ensure the company is educated on the missions, each member is required to read the competition manual and take a mission quiz. This helps solidify their understanding of the missions and engineer a custom ROV to complete the missions.

TASK ONE: AIRCRAFT

This task is based off sunken World War II Boeing aircrafts and malfunctioned aircraft during takeoff from the Sand Point Naval Station. An enormous investment of time, money, and technology is located at the bottom of Lake Washington. The aircrafts, specifically their engines, are of interest to museums and collectors. The APL has requested an ROV that can assist with the search and recovery of these vintage aircrafts. Companies must use flight data to locate sunken aircraft and identify the type, before lifting the engine to the surface. To complete these specific tasks, Daedalus II applies the use of its manipulator, lift bag, and aircraft search zone data sheet.

TASK TWO: EARTHQUAKES

This task is centered on the APL's request for an ROV capable of working in the Cascadia Subduction Zone, a convergent tectonic plate extending from northern Vancouver Island to northern California. This area has active sediment accumulation, active volcanism of the Cascade Mountain range, and subduction. It holds the potential dangers of earthquakes, such as a megathrust earthquake in the Puget Sound. The importance of monitoring this area to predict the next earthquake is evident. This mission includes tasks where the ROV must level the ocean bottom seismometers (OBS) and collect seismographic data using a WiFi receiver from the OBS, located underwater. The manipulator, inductive coupling, and WiFi system are used by Daedalus II to complete these tasks.

TASK THREE: ENERGY

Washington State has invested billions of dollars to increase the use of renewable energy and save the environment. A current project involves the implementation of tidal turbines due to the predictability of tidal currents. Research has shown that to optimize tidal energy, turbines should be placed in narrow channels. The APL is supporting the Northwest National Marine Renewable Energy Center's (NNMREC) research and has developed sensors that need to be deployed by an ROV. This task consists of the company determining the optimal location for the turbine, installing an Intelligent Adaptable Monitoring Package (I-AMP) equipped with sensors, such as an optical and acoustic cameras; strobe lights; hydrophones; fish tag receivers; and an ADV to monitor the area. The Daedalus II manipulator, tidal data sheet, and ADV are used to complete these tasks.

4. SAFETY

4.1 SAFETY PHILOSOPHY

Fabricating and operating ROVs poses safety hazards. Company and bystander safety is a core value and top priority to the Daedalus II company. Having a safe and organized work environment increases the efficiency and wellbeing of our members.

4.2 ROV SAFETY FEATURES

ROV Daedalus II was designed to comply with the safety guidelines specified in the MATE Explorer Class Manual. All on board systems are protected by properly sized fuses. Their capacities were calculated from specifications published by component manufacturers. A marine grade emergency power switch rated in excess of the maximum power draw, is wired in-line to provide immediate power shut-off. Power to the ROV is always off unless all members are prepared for the dive. All moving parts are labeled to provide situational awareness of potentially hazardous components. All gear pinch points are shrouded with lexan covers to provide further protection from intrusion. Each thruster has a 3D printed shroud to prevent entanglement and lacerations from spinning propellers. The entire ROV was engineered to have smooth, rounded edges to prevent injury to personnel.

Figure 13: Safety precautions taken while sanding the bottom canister

4.3 COMPANY SAFETY POLICIES AND PROCEDURES

All company members are required to review safety regulations prior to working with tools and machines. Company policy is that all members must wear closed-toed shoes, secure loose clothing, and tie up long hair around the ROV and its systems or tools. Safety glasses must be worn at all times when eye safety is a concern. These policies are not limited to work on the ROV, but during any form of construction. The company implements safety checklists for ROV operations. See Appendix C. All machines, including the drill press, lathe, and band saw, have posted instructions. A Job Safety Analysis (JSA) provides a breakdown of possible hazards, safety, and emergency procedures. This not only increases situational awareness and safety, but also enhances productivity and efficiency.

5. PROJECT MANAGEMENT

5.1 SCHEDULING AND ASSIGNMENTS

To maximize productivity in a timely manner, a Gantt chart provided a visual overview of the company's schedule. See Figure 14. The combination of the Gantt chart and a detailed task list facilitated decisions on scheduling and task allocations. This was essential to manufacturing, refining, and testing the ROV. Meeting notes and attendance was recorded to track ideas, accomplishments, upcoming deadlines, and participation. At the end of each meeting, the company reviewed progress, goals, and assignments to adjust the schedule. The company CEO and COO managed these documents. Notes and schedules were periodically shared within the company. Members completed tasks between regular meetings to improve productivity.

Production of ROV components was managed by priority, risk, and their effect on other deadlines. The influence of a part on a system was taken into consideration when designing, producing, or purchasing parts.

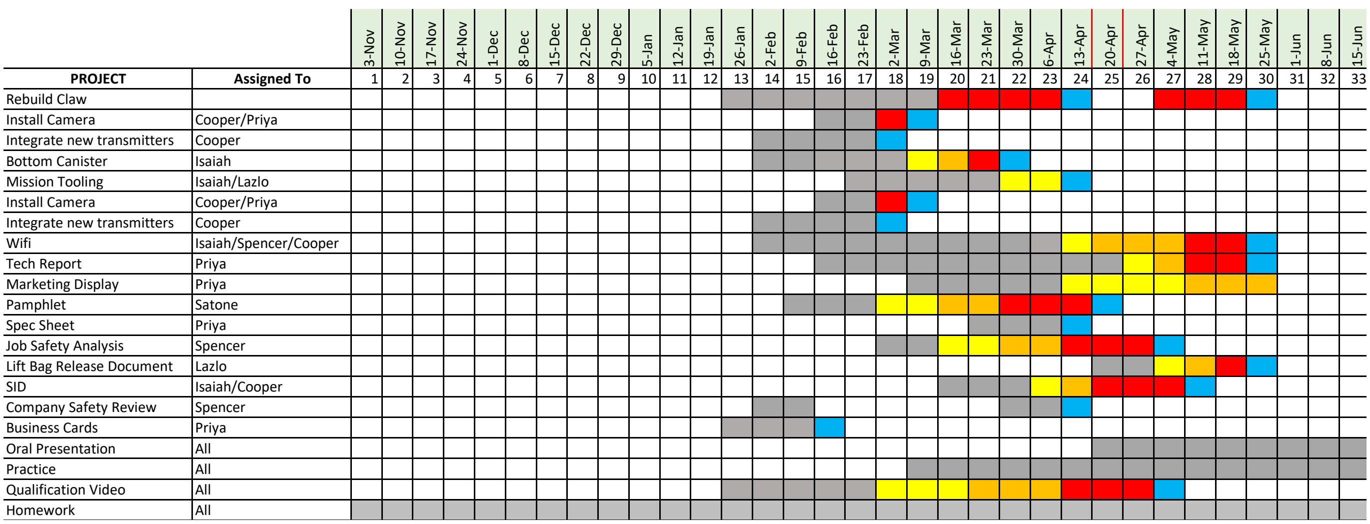


Figure 14: This is a simplified Gantt Chart from the first meeting of the season. The empty section was dedicated to research and planning.

5.2 COMPANY ORGANIZATION AND CULTURE

The employees of Daedalus II strongly believe in educating each other. As a small company, all members participate in discussions on pros and cons before voting on most matters. The large involvement of individuals and constant communication was key to productivity. The availability of information through email and a texting group was essential.

Company positions and subject matter experts (SMEs) were decided prior to the fabrication of the ROV, allowing each specialist to do necessary research and design. SME's worked with other members to ensure that every company member had a basic knowledge of how each sub-system of the machine functions. The distribution of roles was decided by each team member's skills, knowledge, and interests. The achievements of team Daedalus II can be contributed to the cohesive teamwork of the dedicated members. The knowledge, management, and unique skills from each team member have been the key to the successful creation and operation of ROV Daedalus II.

To ensure the company is educated on safety policies, MATE ROV Competition regulations, and missions, each member was required to review company guidelines and read the competition manual. All members took a mandatory quiz after the release of the competition manual to test and solidify their knowledge. The company reviewed previous documents regarding ROV Daedalus to refresh their memory.

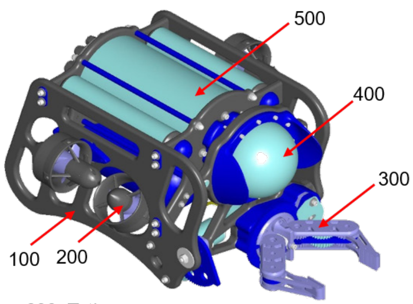
The inspiration for Daedalus II's name and logo came from the Greek character Daedalus who was a skilled craftsman, artist, and inventor. He is credited with creating the Labyrinth and feathered wings that he and his son used to try and escape the island of Crete. His elegant designs and innovation are aspects the company strives for in their technological pursuits. The company logo represents the Labyrinth inside the wings.

5.3 EXPENDITURE SUMMARY

At the beginning of the 2017-2018 season, the company estimated the expenditure for the ROV build season. ROV Daedalus II is the continuation of the 2016-2017 ROV design, resulting in the costly components, such as thrusters and water-jetting, to be a repurposed cost. Based on this information, previous research, and a list of improvements planned for the ROV, the company expected an expense of under $1,000 dollars. This is a sum of the estimate cost for each ROV sub-system. The funds were used to purchase gear motors, sealant material, cameras, a controler, and tooling components.

Due to lack of fundraising opportunities and the comparatively low cost of this year's improvements, the company members agreed to front and donate the money for the build expenses. Sponsorship requests are in progress with several local business and events, such as car washes, are planned to raise additional funds during the summer. See acknowledgements more information on donations.

The estimated travel expense is based on gas to and from Federal Way for three vehicles, three hotel rooms for three nights, and two meals a day per company member for three days. Each member is expected to cover his or her own travel expense, but for simplicity this is listed under purchased.



600 Tether
700 Shore-Side Controls
800 Mission Tools

Total Value	
2018 ROV Build Expenses	$5,760.00
2018 Estimated Travel Expenses	$1,990.00
2017 Total Expenses	$7,750.00
Donation Value	($840.00)
Repurposed Value	($4,920.00)
2017 Net Expenses	$1,990.00

ROV Build Expenses	Expected	Purchased	Donated	Repurposed	Total
100 Frame & Buoyancy	$0.00	$0.00	$0.00	$775.00	$775.00
200 Propulsion System	$0.00	$0.00	$0.00	$950.00	$950.00
300 Mechanical System	$370.00	$0.00	$495.00	$825.00	$1,320.00
400 Video & Sensors	$370.00	$0.00	$150.00	$660.00	$810.00
500 Ship-side Control System	$20.00	$0.00	$15.00	$1,130.00	$1,145.00
600 Tether	$30.00	$0.00	$25.00	$240.00	$265.00
700 Shore-side Controls	$150.00	$0.00	$125.00	$340.00	$465.00
800 Mission Tools	$60.00	$0.00	$30.00	$0.00	$30.00
ROV Build Value	**$1,000.00**	**$0.00**	**$840.00**	**$4,920.00**	**$5,760.00**

Estimated Travel Expenses	Purchased	Donated	Repurposed	Total
A Transportation	$110.00	$0.00	$0.00	$110.00
B Accommodations	$1,520.00	$0.00	$0.00	$1,520.00
C Meals	$360.00	$0.00	$0.00	$360.00
Estimated Travel Value	**$1,990.00**	$0.00	$0.00	**$1,990.00**

Figure 15: ROV Build Expenses by System and Estimated Travel Cost

6. CRITICAL ANALYSIS

6.1 TESTING AND TROUBLESHOOTING

ROV Daedalus II has been subjected to extensive testing both in and out of the pool. Every sub-assembly (i.e. camera assembly, manipulator assembly, thruster systems, etc.) was isolated, dry tested, and then tested for leaks before the ROV was tested as a whole. In a complete systems test, the power and current consumption was verified before the motors were tested individually for the correct forward-reverse configuration. Cameras were powered on and the functionality of the manipulator was tested in all degrees of motion. Following this, the ROV was powered down and placed in the water for extended periods of time to check for any potential leaking and buoyancy. If everything was ascertained to be sealed properly, a complete systems test was performed by piloting through basic maneuvers to check the ROV's functions.

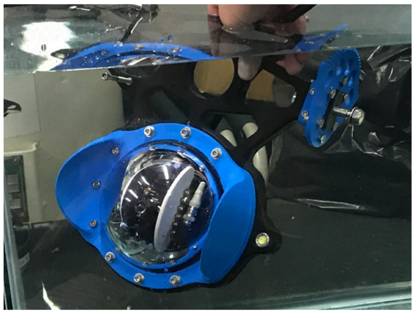


Figure 16: Camera System Leask Test

Figure 17: ROV check after a integrated systems test.

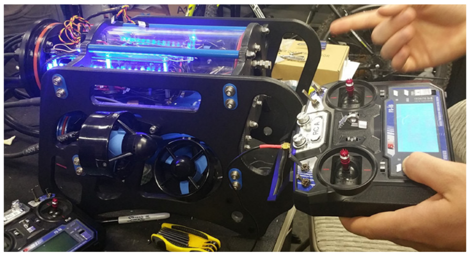


Figure 18: Dry Control System Test

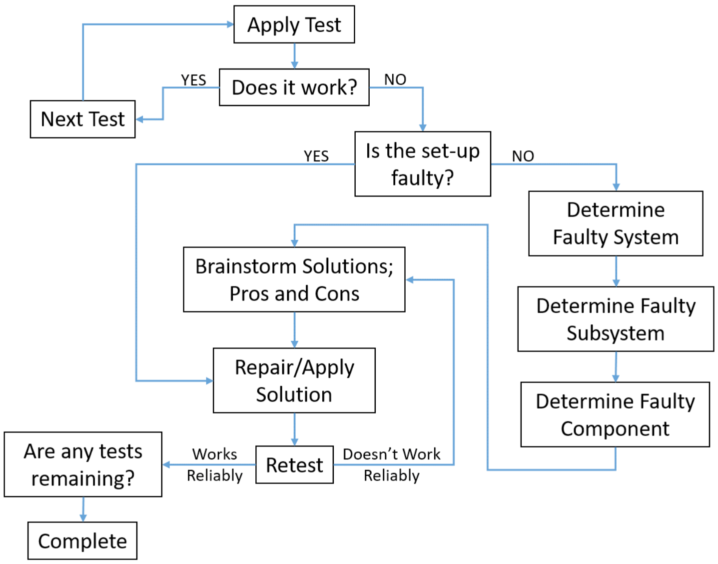


Figure 19: Testing and Troubleshooting Flowchart

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 prototype solutions and if necessary, more tests were performed to better determine the nature of the problem(s) under the consideration of the solutions. In evaluating a prototype's ability to solve the problem, the proposed solutions were tested in a controlled environment. The most effective solution was implemented on the main assembly. If no adequate or rational solution was found or a new problem happened to arise, more brainstorming and testing was conducted to improve the designs using the information from prior trials.

6.2 CHALLENGES

TECHNICAL CHALLENGES

This year, the company identified leak issues. The primary problem was abrasions on the sealing surfaces of the upper and lower electronics vessels, resulting in water intrusion. The source of the problem was determined to be the insertion and extraction of vessel components. This was remedied with several rounds of sanding, sealing, and testing which avert water intrusion during the mission due to these surfaces. Preventative design changes involved covering bolts with shrink wrap.

The development of the WiFi system proved to be a challenge, however careful research, development, and guidance from an industry professional resulted in a solution using a connection from the Bluetooth sensor array developed for last year's competition.

NON-TECHNICAL CHALLENGES

Balancing personal and company schedules and needs were especially challenging this year due to three members beginning college classes and family circumstances which lead to many delays and the need to readjust the schedule. The company repeatedly reassessed the circumstances and availability of individual members. Implementation of new deadlines, reallocation of tasks, follow-up communication, and online meetings for those not available in person helped balance the needs of the company. The frequent and clear communications through a texting group improved the company support system.

Although an improvement over last year, the completion of tasks in a timely manner was a challenge. A Gantt chart was laid out to manage time for manufacturing and installing improvements, purchasing components, and troubleshooting. Though several of the earlier tasks were completed effectively, initial efficiency began to decay due to mechanical issues, leaking, and component failures. This shortened the time we would have liked to use practicing and pushed a few of the required tasks to later dates. To remedy this, more regular meetings were scheduled, allowing more time for practice.

6.3 LESSONS LEARNED

TECHNICAL LESSONS LEARNED

Establishing the WiFi system resulted in many new learning opportunities. This type of WiFi system was not previously used by any of the company members nor Sea-Tech 4-H Club's ROV systems. Through the research and development of this system, company members learned the inner working of a WiFi system, basic coding, and assembling of WiFi components. Sending signals through water opened up new learning possibilities of WiFi applications.

This year, the company realized the need to be more thorough and prompt when remedying an issue. Despite multiple attempts to fix the vessel leak issue, proposed solutions failed to provide long term results. This caused an adverse domino effect on the build schedule. Through the repeated attempts to produce long term results, the company learned of new materials for sealing and repairing seal damage.

INTERPERSONAL LESSONS LEARNED

Some miscommunications led to confusion when purchasing or attempting to integrate components. Communication was key to coordinate and schedule tasks in a practical and timely manner, maximizing company collaboration. It enables the company members to work individually and contribute to the overarching company goal and reducing errors. Promotes efficiency by reducing uncertainty of counterpart progress, risk and impact of unexpected delay of crucial tasks by other members. Gaining common knowledge of a specific issue in a timely manner can minimize the delay and adverse company impact.

This reduces stress and discouragement on individual members by providing team support. In return, it maintains the workflow and avoid setbacks. It can also elaborate individual and team effort and engagement. Effective communication is an integral part of company progress.

7. FUTURE IMPROVEMENTS

For future ROV's, the company plans to conduct most of the research during the summer prior to the build season. Doing so, would allow for a more focused and less stressful development process, enabling the company to have a working machine earlier in the year. This would provide extra time to accommodate unexpected delays and pool practice.

The ROV design will be improved by accommodating more space in the vessels for tracks to prevent leaks from the insertion and extraction of vessel components. A more spacious layout of waterproof compression seals for wire entries and connector between the two main vessels instead of a continuous cable make working on ship-side electrical components more efficient. A detachable tether would provide a less taxing transportation of ROV components when they are being worked on.

8. REFLECTION

Despite the challenges the company faced, working as a team this year provided a great learning experience. Technical skills, project management, presentation, documentation, and teamwork are only a few of the numerous ways in which the company members have expanded their skills. Building on previous year's experiences through the new challenges this season provided has created a stronger foundation for the team's future. The members look forward to applying the newly acquired knowledge to their future endeavors, including competitions, academics, and occupations.

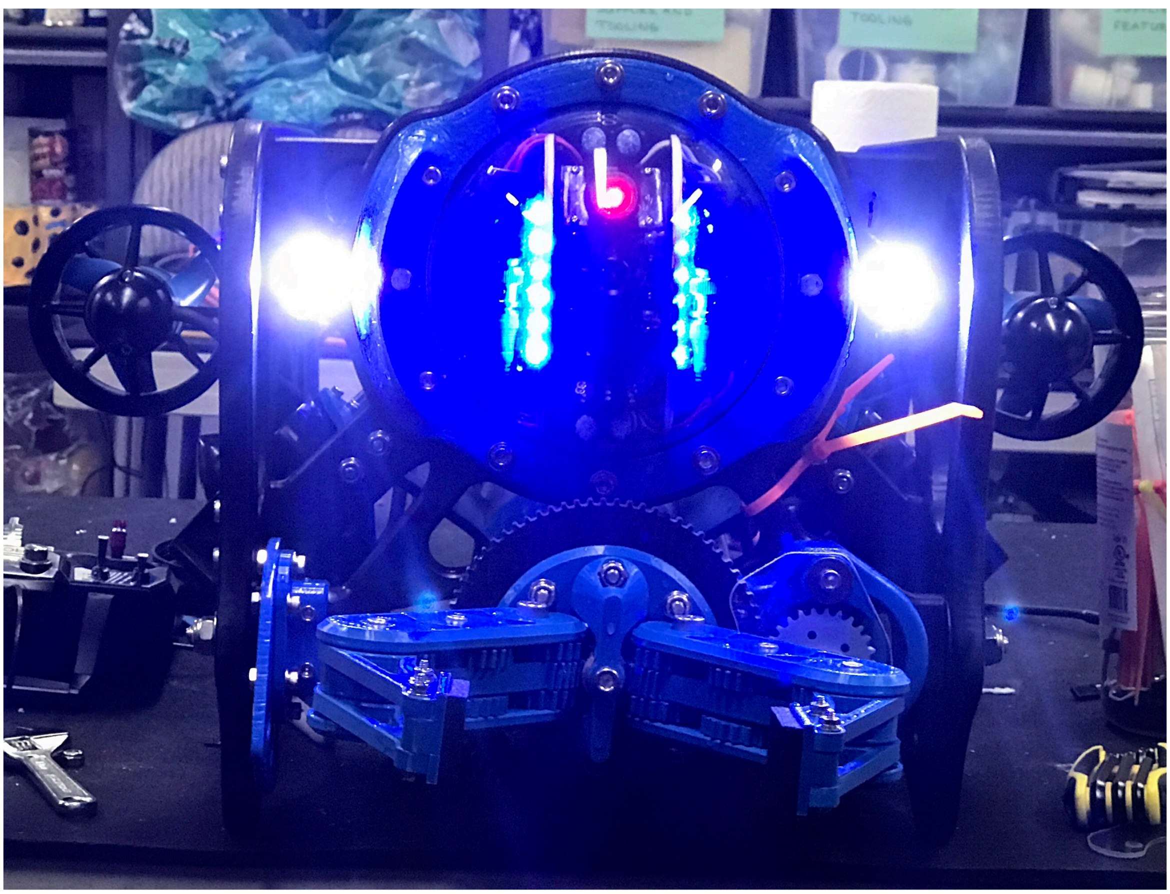


Figure 20: Daedalus' First Integrated Powed Test

9. ACKNOWLEDGEMENTS

Daedalus II would like to acknowledge and thank all the people and companies that have supported them though guidance, services, and materials.

Marine Advanced Technology Education - Sponsoring this year's competition

Washington State University 4-H Extension - The opportunity and club encouragement

Janicki Industries - Water-jetting, Materials, Monetary Donation

Outland Technologies - Tether

MacArtney Underwater Technology - SubConn Connector Discount

Vicor - Vicor Power Bricks

Vertex Aviation - Alodine Aluminum Prep

SolidWorks - Donation of SolidWorks 3D Software

Microsoft - Monetary Donation

HP - Laptop

Kotal Family - Pool Use

Jack Williams - Monetary Donation

James Harvey - Soldering Lesson

Eiji Haratani - Welding

Lee & Shannon McNeil - Guidance, Usage of Tools, Facility, Meals, Monetary Donation

Ric & Cindy Ristow - Guidance, Monetary Donation

Jay & Amy Cocheba - Guidance, Monetary Donation

Marty & Shylan Houghton - Guidance, Monetary Donation

Sundeep & Yoko Kumar - Monetary Donation

Sea-Tech 4-H Club Families - Support

10. REFERENCES

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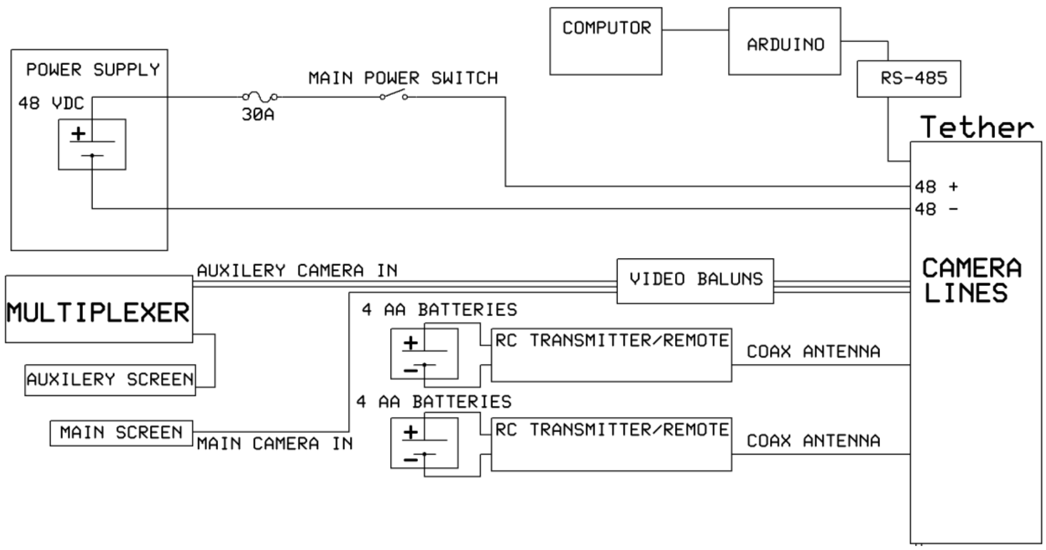
4. Geekstips: Internet of Things Communication Between ESP8266 Modules https://www.geekstips.com/two-esp8266-communication-talk-each-other/

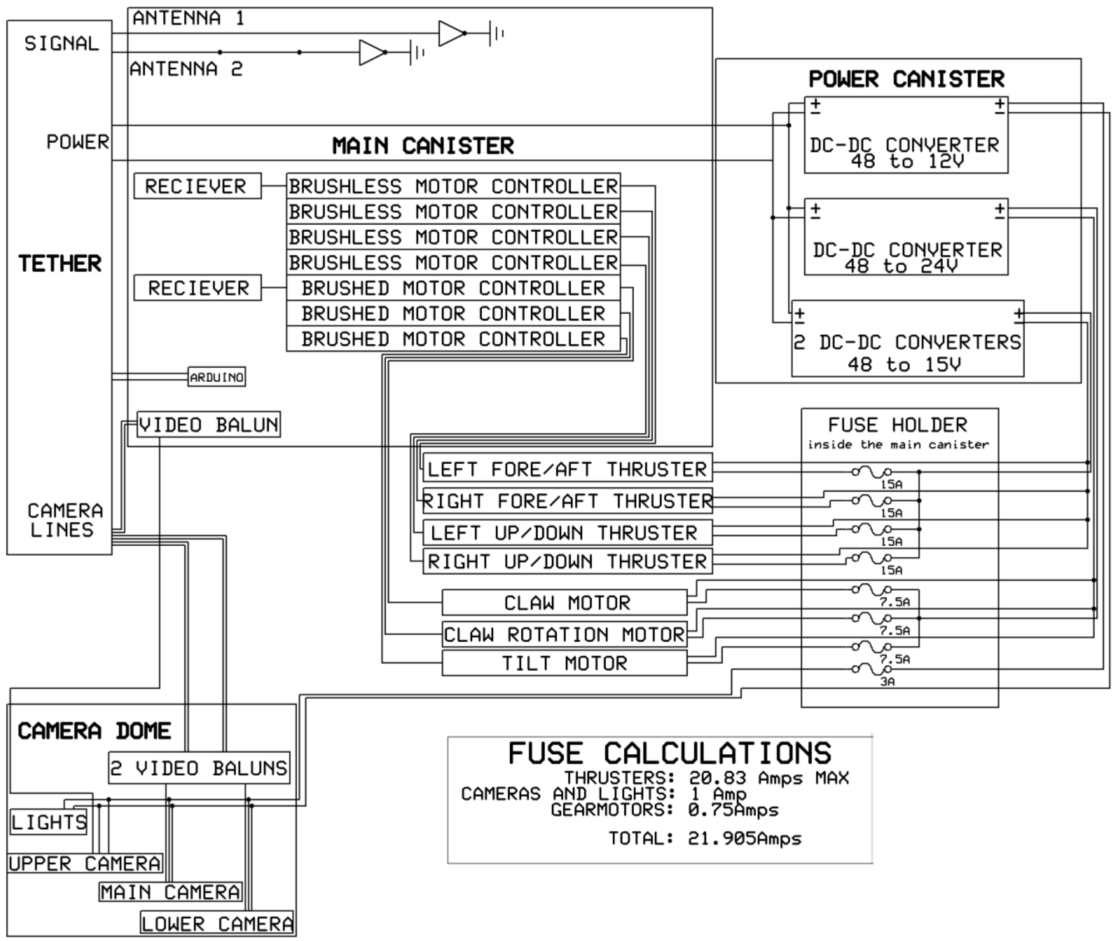
11. APPENDIX

APPENDIX A: SID



Shore-side

Ship-side



APPENDIX B: OPERATIONAL & SAFETY CHECKLIST

Company Members: ____ Date: _______________

DAEDALUS II OPERATIONAL & SAFETY CHECKLIST

Sea-Tech 4-H Club located in Mt. Vernon, WA, USA

OPERATIONAL INVENTORY CHECKLIST			
	ROV Daedalus II		Monitors #1 & #2
	RC A & B		Multiplexer
	DC Power Cable		Mission Tools: Laptop, Lift Bag, ADV

OPERATIONAL SAFETY HAZARDS	
	If bubbles, loss of communication, or other abnormal ROV behavior occurs: refer to JSA
	Prior to powering on or ROV test say “Is it clear?” wait for response “clear”
	Hands off controls (and power off when possible) when working on the ROV
	Be cautious of tripping/slipping hazards (tether, wires, water, etc)
	Wear safety glasses, remove loose clothing, tie up long hair, etc
	Keep junction box clamped to table at all times
	No excess tether left uncoiled on deck
	All cables and connections should be secure and neat

SET-UP CHECKLIST	
	Place ROV and tether out of the way at launch location
	Clamp junction box to table
	Connect power to monitors and multiplexer
	Connect RC controllers to junction box
	Power on RC controllers before powering on machine
	Connect multiplexer to junction box and monitor
	Connect DC power cable to Anderson connector and junction box
	Set-up mission tools
	Make sure upper and lower canister valves are shut
	Make sure cable connections, upper, and lower canister o-rings are greased
	Make sure all cables are connected
	Power on and test ROV systems

TEARDOWN CHECKLIST	
	Power off ROV
	Power off power supply
	Disconnect Anderson power connector
	Power off and disconnect RC controllers
	Disconnect multiplexer
	Power off and disconnect monitors
	Coil tether neatly
	Clean-up mission tools

Notes: ____

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APPENDIX C: CAD MODEL IMAGES

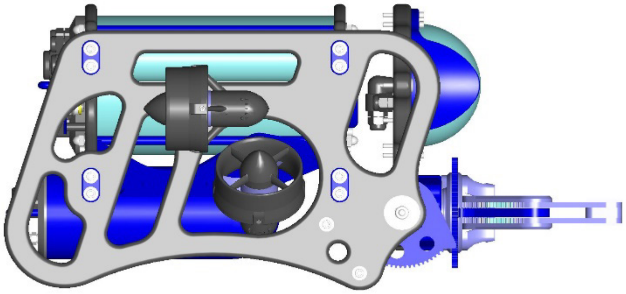

Figure 21: CAD Image 1

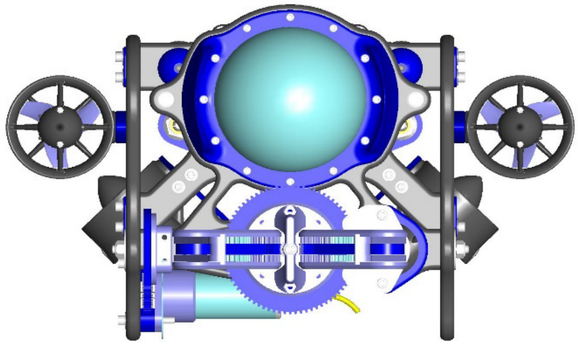

Figure 22: CAD Image 2

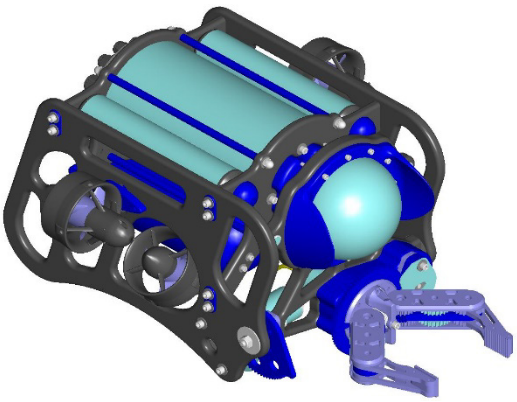

Figure 22: CAD Image 3

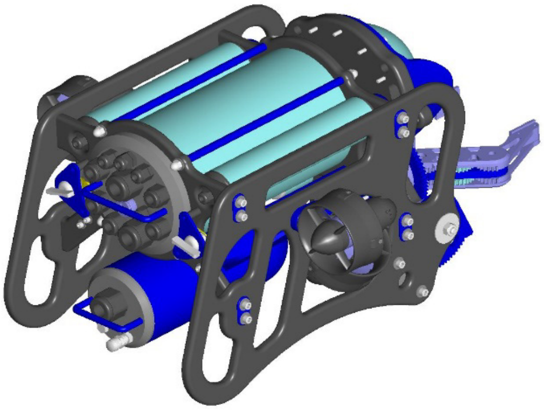

Figure 23: CAD Image 4

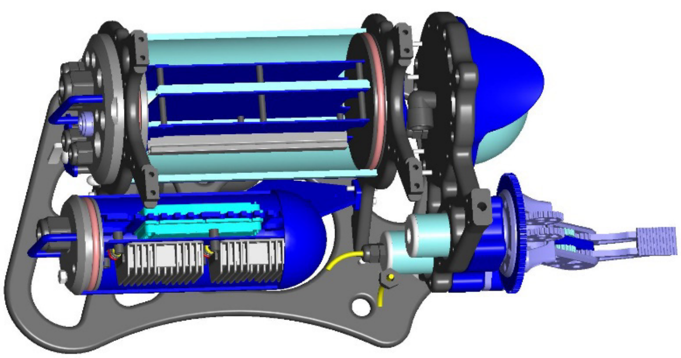

Figure 24: CAD Image 5

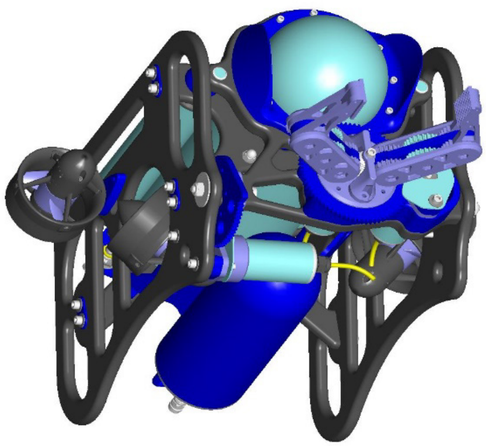

Figure 25: CAD Image 6

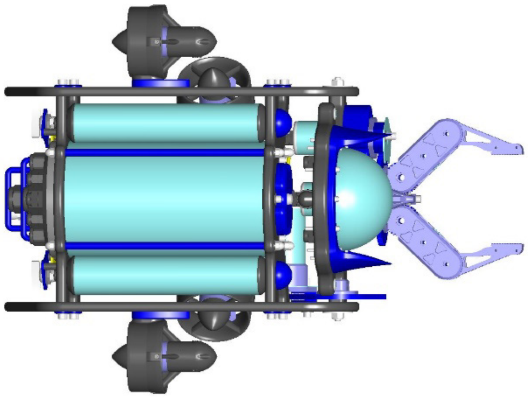

Figure 26: CAD Image 7

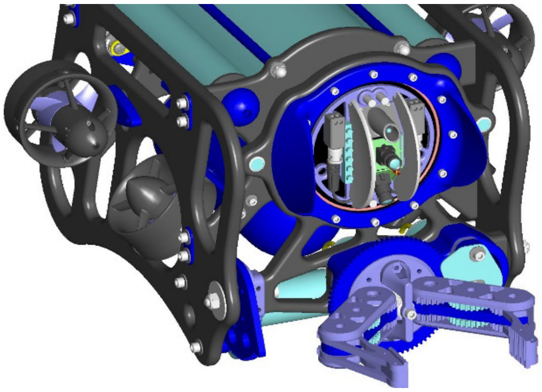

Figure 27: CAD Image 8