Washington State University Vancouver ROV

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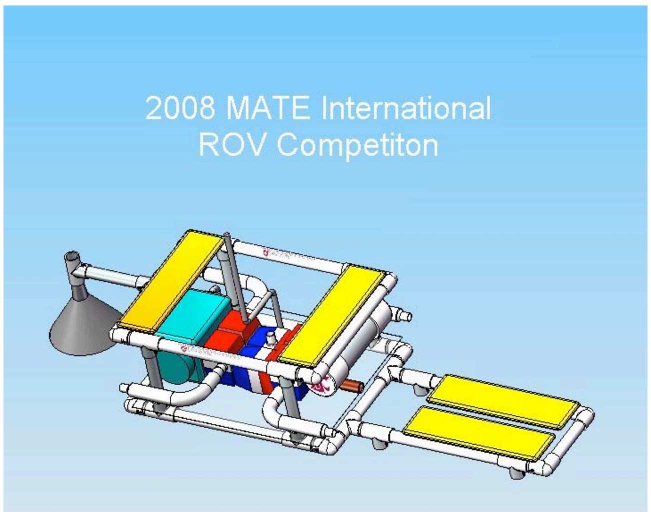

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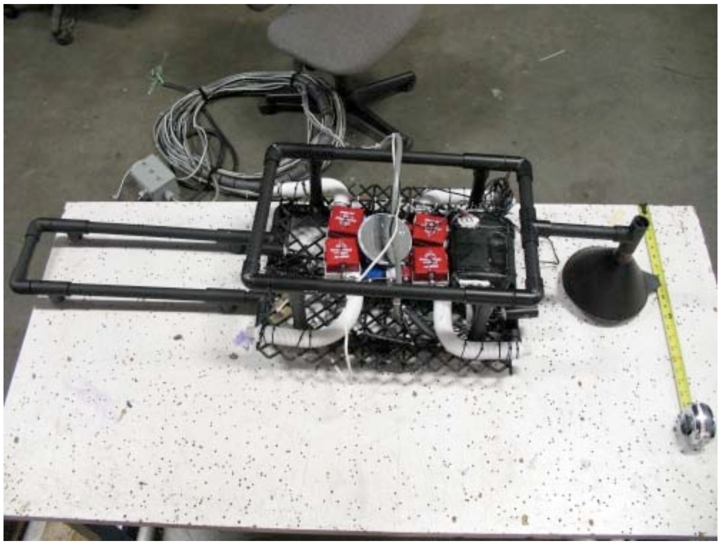
Abstract

Understanding the process is an important part in any task. This technical report covers the WSU Vancouver ROV team's process of building and designing their ROV for the 2008 MATE International ROV Competition.

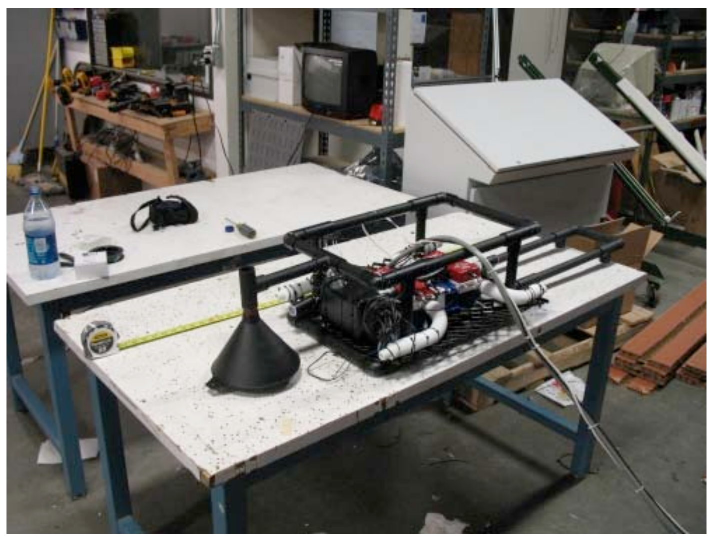
This project was funded by generous donations from multiple contributors and involved a complex design process. Through generous donations, the team carefully budgeted funds for this building project. For the design, the team first came up with a rough design and then refined the idea through tests and calculations. Then a basic ROV design was made and built with modifications made as necessary. In the end, the team created a box frame with a temperature probe and a fork, which bilge pumps powered the propulsion system.

Reflecting on the project, the team was faced with multiple challenges, which the team overcame. To overcome technical problems, the team used a consistent method throughout the project. The team learned many lessons and skills in this project. This project also offers room for improvement. In the end, the team learned a great deal ROV and applied learned knowledge to real world situations.

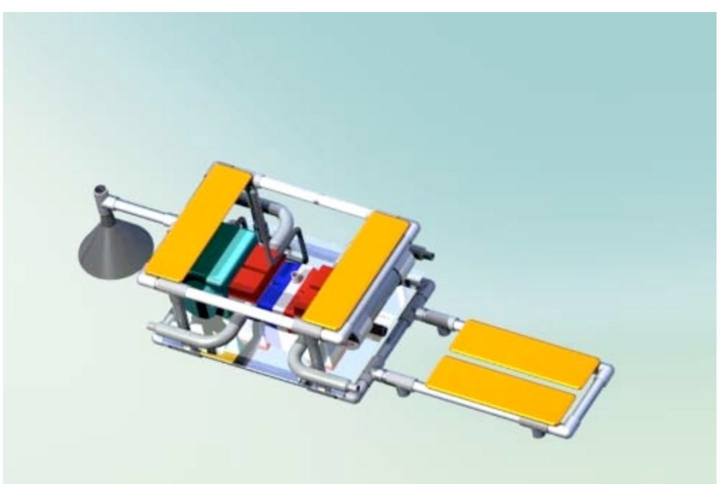
Photographs of ROV



Top View of ROV



Diagonal View of ROV

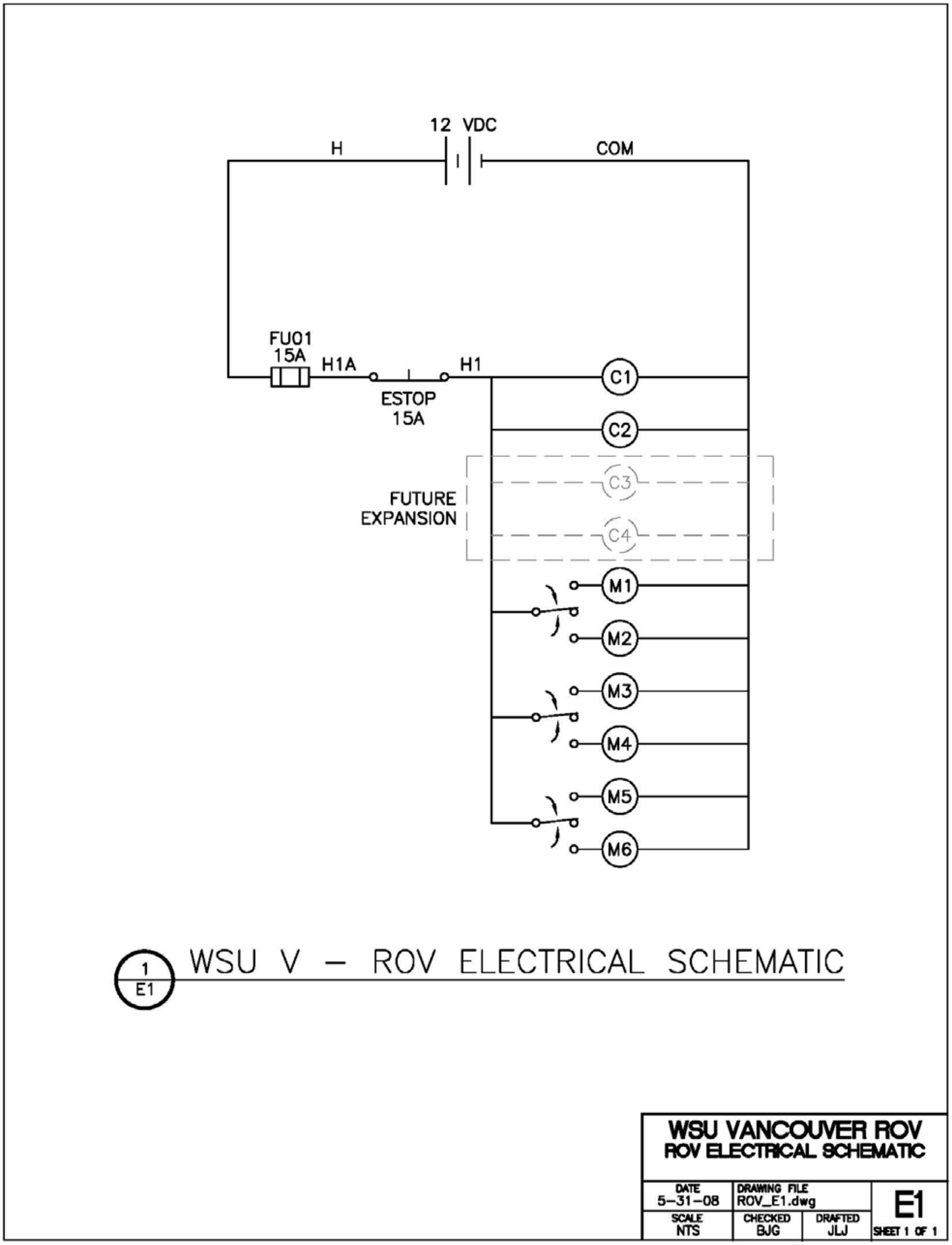


Isometric View of ROV
Rendered in SolidWorks

Budget/Expense Sheet

Part	Qty	Cost	Subtotal	Notes
15a fuses	1	$7.50	$7.50	Bag of 15
Bilge Pump Hose	14	$4.00	$56.00	Only 8 feet used
PVC elbows	10	$0.24	$2.40	
PVC pipe	3	$6.80	$20.40	
7.62cm Dia ABS	2	$25.00	$50.00	For OBS mock up
PVC end caps	8	$3.00	$24.00	
PVC Tees	16	$0.42	$6.72	
Funnel	1	$6.99	$6.99	For Temperature Probe
Digital Thermometer	1	$70.00	$70.00	For Temperature Probe
Security Camera	4	$59.99	$239.96	
Bilge pump (0.79 L/s)	6	$34.99	$209.94	Used as ROV Thrusters
Playstation Joystick	3	$10.00	$30.00	Not used for build
LED Maglites	4	$25.00	$100.00	Not currently installed on ROV
Clear Plastic Sheet	1	$7.00	$7.00	For camera housing
7.62cm Dia ABS pipe	1	$23.99	$23.99	For OBS mock up
1.27cm PVC elbow	12	$0.30	$3.60	For OBS mock up
1.27cm PVC tee	6	$0.40	$2.40	For OBS mock up
1.27cm PVC pipe	2	$5.20	$10.40	For OBS mock up
Valve Stems	4	$3.00	$12.00	For Ballast Bags
Dry Suit Material	4	$0.00	$0.00	Donated by Thunder Reef divers from Factory scraps
19 AWG Conductor Cable	70	$1.00	$70.00	Donated by Prairie Electric for our tether
Wire Terminals	10	$1.00	$10.00	Donated by Prairie Electric for our electrical system
Emergency Stop Operator	1	$20.00	$20.00	Donated by Prairie Electric for our electrical system
Metal enclosure	1	$60.00	$60.00	
3-way Toggle Switch	3	$15.00	$45.00	
Shipping Costs			$200.00	Includes the shipping costs for any items purchased via the internet
Shop Costs			$100.00	Includes pvc glue, tools, waterproofing materials, and other misc. goods
Total			**$1,388.30**	

Electrical Schematic



Design Rationale

We started this project by reading and digesting the specific missions for the 2008 competition, getting a temperature reading from the black smoker, rescuing the Ocean Bottom Seismometer (OBS), and collecting three lava samples from the OBS.

Our first major design decision came when we decided on a frame style. First, we thought about a submarine type structure. However, we decided that although it might save time by being more aerodynamic, it would be very difficult to control and would need a much more complex control system. We then settled on a simple rectangular cube design; which proved to be easier to build and operate in the water. With this design finally nailed down, we then had to make a decision about what material to use for our frame. We chose Polyvinyl Chloride (PVC) tubing because polyvinyl chloride is easy to use; as we can bond it permanently with simple gluing procedure. Also, the PVC can be cut using a chop saw to make sure that the cut is perfect and all similar pieces are the same length.

We decided from the start that the temperature reading would be the simplest task to accomplish; all we needed was a large funnel and a temperature probe. We decided to use the funnel because we would be able to get an accurate reading without having to get the tip of the probe right into the flow of warm water. With the water being funneled right past the probe, we stand a much greater chance of getting full points for an accurate reading. This also saves time by not having to get right into the flow of water.

Next, we tackled collecting the samples; our first though was to use an arm to grab each sample and put it into our ROV, then clear the rest, and let the OBS float by its self to the surface. So then we designed a simple arm, a scrapper scooping up the beanbags, but then decide that this posed far too many obstacles. Then, we came up with an idea to just float the whole thing, lava samples and all at the same time by inflating air bags underneath. This proved to be a simpler design, with less chance of mechanical failure. Using the air bags, all we have to do is maneuver the forklift like apparatus on our ROV under the OBS and inflate the bags via a bike pump. Using two different bags, we should be able to control side-to-side pitch by just inflating one bag more then the other. By inflating the bags until they make the whole OBS just positively buoyant, we can then use our thrusters to move the unit to the surface and collect our samples.

We decided from the beginning to use bilge pumps for our thrust, as they are inexpensive and easy to install. Also, they are designed to be used in marine settings so they are already waterproof. With their plastic bodies, they easily mounted to the frame with zip ties and they are easy to replace if needed. The pumps have a low amp draw when run with 12 volts DC power source, only about 3 amps per motor. With our system, we can fire three motors at once, so the most the motors can draw is 9 amps. Also, the pumps can be mounted in a central location and the thrust piped to the desired location. Our layout allows for a tank tread style, allowing the ROV to turn on a central axis; which will be useful when trying to maneuver the temperature probe into the water flow and when directing the forklift arm under the OBS. Overall, this is a simple system that can be adjusted and fixed with ease.

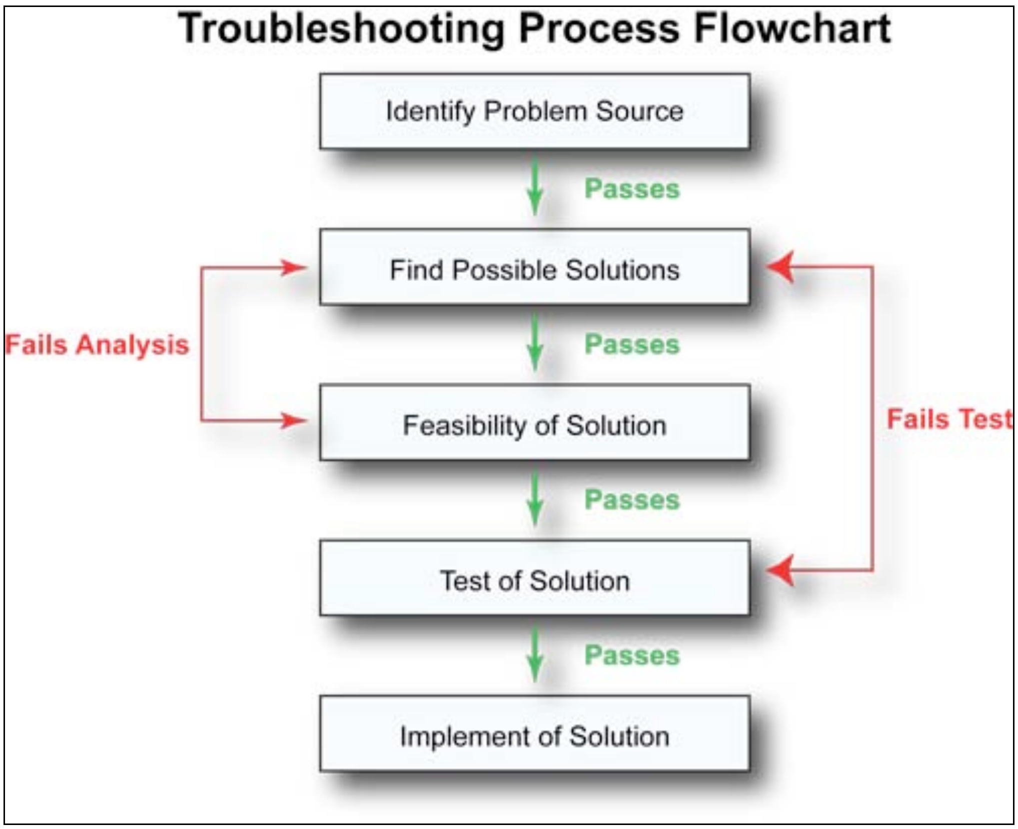
Description of a Challenge

One challenge that our group faced was acquiring funds for our ROV. After a vigorous search, we were able to acquire funding through generous contribution by the WSU Vancouver

Student Government. The problem that we faced here was to order anything we had to use purchasing orders (PO). Some companies did not take PO's and ordering online became pretty complicated. Some solutions we came up with to fix this problem was to seek other funding such as a Wal-Mart grant that would allow us to cash a check and therefore not have to use PO's. Our group also went to cheaper alternatives and more cost effective solutions. For example our thruster system is cheap and simple, but still propels our ROV without any trouble.

Troubleshooting Technique

Throughout the build process we used a specific troubleshooting technique to solve problems. This technique worked very well for our group. Below is a flowchart displaying our troubleshooting method.



An example of using our troubleshooting method came when we had to build our lift bags to place under the OBS. At first we tried a glue that was recommended by the dive shop that supplied us with the material to make the bags. But the glue did not create a seal that would hold air pressure; since we plan to use this to raise the OBS, the seal would have to hold a substantial amount of pressure. When the glue did not work, we went back to the feasibility step and looked at a different method; we used the glue we used to make our frame. But this also failed the test; it would not hold any air pressure, therefore failed the test.

Now once again, we had to start back at the beginning and try to come up with another solution. We tried to melt the vinyl together and create an airtight seal we are looking for; using a heat gun and a seam iron we heated the material to a point where it was almost melting then used the seam iron to melt and create an airtight seam. This method proved to be feasible solution so this is what we used to create our lift bags that are cut to shape then sealed up using the above process.

Lesson Learned

An important lesson we learned was how to apply the physics, statics and dynamics we have learned in our classes to real life events. A concept from physics that we used was calculating buoyancy to determine if our ROV would sink or float. We used physics to approximate the size of the ballast tanks needed. That way we could decrease materials wasted through trial and error. A good example of using concepts from statics was to calculate the stability of our ROV. Using the concept of moment we were able to calculate how much moment a load would generate, then we could adjust our ROV accordingly. This was very helpful to keep our ROV upright and not tilt to one side making it easier to control the ROV.

Future Improvements

In designing our ROV we have noticed that there is room to enhance the ROV's performance. Improvements to the ROV were restricted this year due to insufficient funds and limited design time. However, next year we plan on improvements such as upgrading from pumps to thrusters, designing a more complex control system, increasing stability of the ROV by including ballast pumps, and designing a less restricting tether for the ROV. To successfully achieve these improvements, we have started fundraising and designing for a more complex control system for next year's competition.

Research Project Relating to ROVs

Researchers from Duke University, Woods Hole Oceanographic Institute (WHOI), Universities of New Hampshire and South Carolina discovered a new underwater hydrothermal vent, or "black smoker" in nearly 2.6 kilometers of water. This new black smoker was found off Costa Rica in the East Pacific Rise, a mid-ocean ridge in the Pacific in April of 2007.

Due to the depth, humans would have been unable to explore this area without the assistance of Jason II, a Remotely Operated Vehicle (ROV). But depth was not the only challenge facing Jason II. The normal water temperature at 2.6 km underwater is 2° C. The temperature that Jason II logged at the vent opening was 335° C. The extreme range in temperatures made Jason II's tasks more challenging, but the ROV was able to assist the scientist aboard the R/V Atlantis, WHOI's research vessel, to make amazing discoveries.

Jason II was not alone at the ocean floor near the hydrothermal vent.


Credit: WHOI

Surrounding the ROV were many organisms including pink bell-shaped jellyfish and two types of tubeworms, an organism often found near black smokers due to its heat tolerance. Due to the tubeworms and the jellyfish, which were from the jellyfish order *Stauromedusae*, the researchers named the vent Medusa.


Credit: Image courtesy of Duke University

Jason II allowed the team to find this rare jellyfish type, something the researchers may never have experienced without the assistance of a ROV. Also, Jason II's mechanical arms allowed the team to take samples of the vent's volcanic rock and biological samples and then return them to the surface for further investigation. Between using its cameras and arms, Jason II was able to provide the scientists with new data about this extreme environment that would not have been otherwise possible. Jason II accomplished this while the team was safely aboard the

Atlantis absorbing the images of the depths that it was sending back via its tether. Jason II and ROV's like it are able to extend the knowledge of science further than ever before. They can enter hazardous environments allowing humans to better understand these places that were once out of our reach and understanding.

Reflection

In this project, we learned a variety of concepts applicable to real world situations. We applied learned concepts into a real world situation. For example, we used concepts learned in physics, statics, and dynamics to estimate the requirements of parts to avoid failure. Other than applying learned knowledge, we also learned new real world skills. For example, we learned how to market a proposal to an audience and maintained a budget for a project. Also, this project introduced us to the potentials of a ROV. Overall, this project allowed us to learn and use skills applicable to real world situations through building a ROV.

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Sarkinen, Duane. Professional Advisor.

Willamson, Dale. Professional Advisor.

Acknowledgements

We would like to thank the following people and organizations for all of their help throughout are design process and competition:

- Jill Zande – Competition Coordinator
- Dr. Rad Hamid – Team Facility Advisor
- Lee Juhala – Prairie Electric Donation Organizer
- ASWSUV – Associated Student Body of WSU Vancouver, primary funding source
- Thunder Reef Divers – Donator
- Prairie Electric – Donator
- Instructional Tech – Donator