Technical Design Report

Abstract

The efficiency of completing each course of the 2021 SeaPerch competition can be improved by maximizing forward thrust and minimizing drag and turbulence. Therefore, these two hydrodynamic concepts were the primary focus of the design of our remotely operated underwater vehicle (ROV). We optimized individual components of our ROV for these concepts while being conscious of streamlining and simplifying for an overall improved hydrodynamic profile. We accomplished this through a heavy focus on research into scientific and engineering principles as well as extensive testing using computational fluid dynamics (CFD). Particularly, our thruster mounts were developed with research into the principles of Kort Nozzle design and modifications from CFD results. In addition, the entire frame was optimized with hydrodynamic shapes wherever possible.

Beyond hydrodynamics, a secondary focus for our design was to examine and rectify every other issue we faced in detail. We believe it is important to learn from the existing body of scientific knowledge, as well as being boldly innovative in reexamining even the seemingly fundamental components of our design. Therefore, we reimagined traditional processes such as waterproofing and object recovery methods. Combined with other enhancements to our design, our commitment to improving every individual component of our design process is central to our ROV.

Course Overview

Continuing from the 2020 season's competition, this year's challenge features several different recovery objects as well as interactable obstacles that will be completed to accrue points. The full Seaperch Waterway Cleanup course is divided into a total of two runs, each with two tasks and having a two-minute time limit. The first run contains both the active mine PVC obstacle and the disposal vault system. An ROV will need to "disarm" the mine by rotating a 4-way PVC segment from its aligned base, then remove and place it in a disposal area at the pool floor. After, the ROV must rotate a latch holding the vault shut. The ROV should then collect a weighted object on the pool floor to deposit on the opened latch, closing the vault once again. These tasks cumulate for a total of 50 points. The second run contains the final two tasks of the garbage patch and the sunken waste platform. The starting areas are both outlined in PVC with several objects to be removed from the floating patch along with several sunken objects to be deposited in the disposal area. The sites will include various objects such as 16oz and 20oz bottles, a metallic can, weighted spheres, and a floating 6-pack ring. Completing all possible tasks in run two scores for another 25 points total.

Employing a variety of recovery methods that account for variations of size and buoyancy among challenge objects was an essential design goal to successfully complete the course. Because of the diversity of the objects, refining our collection methods to be effective and versatile was a central design goal that led us to test and redesign many different iterations.

Additionally, maximizing the speed and efficiency that we can complete tasks is crucial to scoring higher. Therefore, two design goals that applied to this course requirement included a focus on understanding and applying fluid dynamics as well as increasing the momentum that propellers can impart on the ROV through specialized thruster assemblies. Because of how central this goal was to improving performance in every aspect of the course, we spent a significant portion of our time improving on this design focus area in particular.

Finally, the last design goal led by our analysis of the mission courses were miscellaneous improvements to the performance of the ROV through thorough testing, experimenting, and redesigning, including in areas such as flotation and motor waterproofing.

Design Approach

We began our engineering design process by setting design goals based on the mission courses. We determined that increasing hydrodynamic performance would be beneficial to efficiently complete all courses. From there, we evaluated the strengths and weaknesses of our previous designs. An important part of our design process was segmenting the different components of our design so we could analyze and enhance them comprehensively individually while maintaining a consciousness of the balance of the design as a whole. The strengths of our previous designs that we retained and improved were the characteristics of a light 3D printed frame and centralized weight distribution. Key weaknesses were in hydrodynamic form, motor waterproofing, flotation, and depth sensing (Appendix C, Page 4-5). The next step in our design approach was researching the relevant scientific principles and previous engineering discoveries to apply to our design, inventing new solutions. Furthermore, physical and simulation testing was essential to our design approach to help us test the efficacy of our design solutions and tweak them as needed to improve performance.

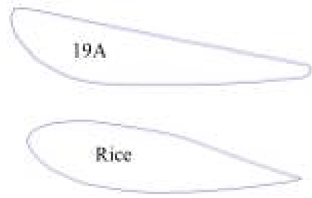
Main Design Iterations		
Figure 1 *Previous: Perseus*  *Note.* Light 3D printed frame, and variable buoyancy syringes.	**Figure 2** *Current: Zeus III*  *Note.* Hydrodynamically optimized, return to polyethylene, new thruster mounts, and improved recovery device.	**Figure 3** *Current: Kronos*  *Note.* Most hydrodynamically optimized, mechanical recovery device, longer and thinner frame, and passive downforce.

Hydrodynamics The hydrodynamics of our ROV was a key focus for improving our design. Teardrop and airfoil shapes are best to minimize drag and turbulence (NASA, 2015; Smithsonian, n.d.). Therefore, we incorporated them wherever possible, as in our thruster mounts and our frame.

Thruster Mounts While previous designs simply guarded the propellers, our current designs apply our research about hydrodynamics and duct theory to increase the volume of water to the propeller while reducing overall drag. This concept has been a key focus of our design process through current and previous seasons (Appendix C, Page 2-3) .

Accelerating ducts were most suitable for our purposes because they increase forward thrust by creating a pressure difference that accelerates the inflow to the propellor (Carlton, 2018). Our first design used the 19A, a standard accelerating duct. However, we discovered a study by researchers from Yildiz Technical University which showed that among accelerating ducts the Rice nozzle provided higher propulsive efficiency than the 19A (Çelik, et al., 2011). Ultimately, we combined our research of duct designs with fluid dynamics to create an original duct that's specialized to our unique ROV design.

Figure 4 *19A vs. Rice Nozzle*



Note. (Çelik, et al., 2011)

Figure 5 *New nozzle and thruster mount design (Poseidon v4.1)*

Note. Profile of Rice inspired nozzle and entire thruster mount in CAD

Flotation The syringes from Perseus (Figure 2) allowed for variable buoyancy, which we could alter for each course, however, this was outweighed by their large profile generating excessive drag and turbulence. We experimented with expanded polystyrene because its malleability allowed us to create a hydrodynamic profile.bHowever, we found that it lost buoyancy after about 15 minutes in the pool. Consequently, we reverted to the tried and true polyethylene from our first design which is buoyant, lightweight, and strong (Foam Factory, n.d.).

Motors The previous waterproofing technique using wax and a film canister, was space inefficient and not completely waterproof, even leading to motor degradation over time (Appendix C, Page 1). Therefore, after considering many alternatives, we decided to use heat shrink tubing to waterproof our motors. When the internal rubber lining of the shrink wrap melts and cures on the motor, this creates a waterproof seal. The new waterproofing method reduced weight by 12g.

Figure 6 *Damage from previous potting method over time*

Figure 7 *Previous vs. new waterproofing method*

Recovery Device Due to the design criteria we identified in our analysis of this season's course, we needed to build our recovery device in a fashion that allowed carrying compatibility with the various game objects. We ended up using a traditional hook, and a passive claw system. This system, named "the Big Irons," is a rotating rod that is tensioned with rubber bands. The force imparted on the bottles by the ROV opens them enough to capture it. The water bottles are released through horizontal rotational shaking or a force applied to the bottom of the lever. Both the paper clips and hook serve to collect submerged debris, with the hook simply carrying heavier objects and the paper clips using tension to collect and retain lighter game objects. Both methods release their respective payloads when the ROV decelerates quickly, allowing for quick disposal.

Figure 8 *3D printed hook With paperclip attachments*

Testing

After the 2020 season abruptly ended, we investigated different methods to test our ROV's performance to innovate and excel by analyzing and rectifying our shortcomings. Reflecting on our previous designs and concepts for new improvement, for example, in many of the components described in our design approach, we recognized the need for more rigorous scientific testing to optimize the execution of our ideas. We accomplished this through two main types of testing, computational fluid dynamics (CFD), and quantitative pool testing.

Computational Fluid Dynamics While the learning curve for CFD was challenging, we found it was also rewarding in providing objective quantitative data demonstrating hydrodynamic flaws. We conducted several simulations of "Perseus" (Figure 1) and discovered that circular supports were inefficient because the flow of water detached from the rear of the support, thus creating a low pressure, turbulent wake. In addition, the flat face of the horizontal motors created a relatively large stagnation region, increasing the pressure of water flowing around it and subsequently generating a wake that decreased the mass and volume of water flowing through the propeller duct. Similarly, key propulsion concepts such as Bernoulli's Principle and our ducted propeller designs were not applied in our thruster assembly design in a manner that yielded any theoretical propulsion increase. Because of the valuable feedback about our application of fluid dynamics and underdeveloped areas, we were able to engineer significant improvements for our next design.

Figure 9 *Stagnation areas, shown in darker colors, increase drag*

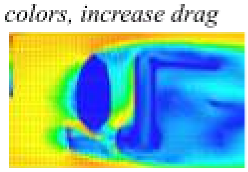
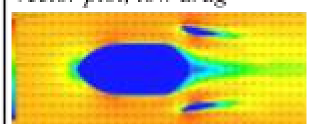


Figure 10 *Rice-inspired nozzle bisecting velocity vector plot, low drag*



I. Zeus & Zeus III Our growing proficiency in CFD allowed us to transform our design language by giving us the ability to effectively orient our design on hydrodynamic performance and maximizing water intake and velocity to the propeller. As a result of CFD, we've been able to accelerate our rate of improvement in areas such as speed significantly.

For instance, CFD results showing excessive turbulence in our CFD simulation highlighted how our ROV could be improved through the adjustment of our thruster assemblies, both through research and continued adjustments. The ability to do continuous and repeated scientific tests through CFD allowed us to make a breakthrough in rectifying this issue by the creation of vents, which significantly increased downforce, as in Figure 9. CFD continued to be a crucial part of our process, as we combined its feedback with our research to optimize the thruster mounts for our specific purposes and ROV, as opposed to the large tugboats the 19A and Rice ducts were designed for.

With Kronos being more meticulously examined in CFD examining the hydrodynamics of the simulation, we raised our standards for how the water flows and the streamline of the ROV, such as minimizing all areas of flow separation. With our old motor mounts, there was a lot of detached flow when the water went around the motor mount and into; adhered more to the boundary layers so used the mass and volume of water flowing into the propeller. Consequently, our ROV tested 5% faster despite only being 1g lighter.

ROV Model	Mass (g)	Velocity (m/s)	Speed % Increase
Hermes	602 grams	0.47 m/s	N/A
Perseus	464 grams	0.48 m/s	2.13%
Zeus	450 grams	0.65 m/s	35.42%
Zeus III	343 grams	0.80 m/s	23.10%
Kronos	342 grams	0.84 m/s	5.00%

Pool Testing Each design iteration was evaluated in a submerged pool environment for both top speed and maneuverability. Using straight-line speed as a benchmark for overall propulsion efficiency, we were able to quantitatively evaluate the effectiveness improvements incorporated into each of the four designs. These tests were used to corroborate our simulated testings and were of great benefit to our design process.

Figure 11 *"Hermes" Testing*

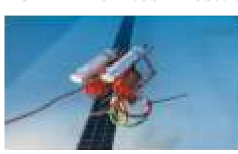


Figure 12 *"Zeus III" Testing*

Reflection and Next Steps

Due to the onset of COVID-19, we were in a primarily virtual environment and did not have access to the same physical resources and hands-on experimentation we had the privilege to experience in previous years. However, we were determined to persist in improving our ROV and to adapt to new circumstances, just as the engineering process demands of us.

Consequently, we learned to treasure how research and simulation can elevate our designs. For our ROV this year, our goal was to create the simplest and most hydrodynamic design possible. We believe we accomplished this goal largely because we let research and testing have an immense impact on our design approach. In some sense, because we were forced by the pandemic to take the time and space to step back from physical aspects and focus on the concepts and scientific principles, we excelled in the nuances of our design. In the future, we would like to continue to apply this lesson by continuing to place significant value to research and testing as tools to bring our designs, SeaPerch or otherwise, to the next level.

While we have made significant developments to our ROV over the course of the year, there were several improvements we wanted to apply to our design that we were not able to, either to skill, time, or budget constraints. While we made a lot of progress on refining our ROV hydrodynamically this year, as it was a key focus, we also want to continue to work on perfecting in the future.

Generative Design We are also really interested in investigating generative design, where we could potentially use computerized structural analysis to optimize our design for certain constraints, such as determining to reduce material while increasing rigidity.

Depth Sensor System One significant challenge we experienced while operating the ROV was assessing the depth of the ROV. The refraction of light as it changes mediums from water to air can affect the angle and size as it appears to the driver, making it difficult to determine the exact location and depth of the ROV. Therefore, we have worked with different methods towards developing a cost-efficient depth sensor system, starting from LED lights (Figure 2), which was unsuccessful because they had the same refraction issue. During this season, we attempted to create an aquatic depth sensor using a combination of a pressure sensor and an Arduino microcontroller. Although we were not able to complete it in time for our official competition, we still have a strong desire to implement into our future designs.

Flotation While we did attempt to create more hydrodynamic flotation this year through using more moldable polystyrene, we were thwarted by the issues that polystyrene faced with buoyancy, and decided to return to using polyethylene. Flotation, while an extremely essential component of the ROV, has been a continuous issue for us in its obstruction of the hydrodynamic profile that we have spent so much time perfecting. In the future, we would like to continue our work to refine our flotation with the hydrodynamic principles we have applied to the rest of the ROV and incorporate it better into our design as a whole.

Conclusion SeaPerch has been an integral part of our high school experiences. While creating an ROV seemed a daunting task when we each first began, the community and teamwork we found helped us become increasingly comfortable to discuss our ideas and participate in a mutual creative space. The technical skills we have learned have helped us make our ideas reality. We will continue to use skills that we have developed through SeaPerch, including research, CAD, circuitry, CFD, experimentation, and technical writing, as we pursue engineering as a means to make the world a better place.

Right now, we're continuing to give back to the community in a variety of ways. Because of the difficulties we had trying to learn CFD due to the lack of resources, we are currently working with RoboNation to create videos teaching the software, so that other teams will be able to learn how to apply it to their own designs. We hope to continue to be part of the SeaPerch community for many years to come, as each of us go off to university and pursue our interests in STEM fields and professions.

Acknowledgments

Foremost, we would like to express our utmost gratitude to Mr. Quast, who has diligently continued to run SeaPerch and provide us with the resources and environment necessary to safely continue to work on our ROV in the midst of a pandemic. In addition, we thank our club officers, Alana and Bernadette, for taking on the responsibility of making sure everything goes smoothly and being leaders for the club in these trying times.

Without a doubt, our current team would not have been possible without the help and friendship of our past team members. AJ and Andrew, having both since moved away or graduated since their time with us in SeaPerch helped us immensely from the start during our freshman year, all the way up until last season. We extend our gratitude to them as well.

We also sincerely appreciate the help of Dr. Shubham Srivastava, group leader of engineering simulations at Rheem Manufacturing, for providing guidance with CFD and the hydrodynamic principles that we applied to our ROV. Furthermore, we would like to thank Onelife Fitness and Ms. Roxane Rachocki for allowing us to use their pool for testing. Finally, we are very grateful to our parents for always supporting us to pursue our dreams of engineering and providing everything for us to be where we are. We could not have accomplished what we have without the generosity and kindness of all of these people.

References

Carlton, J. (2018). Chapter 22 - Propeller Design. In Marine Propellers and Propulsion Ed. 4. Elsevier Science.

Çelik, F., Doğrul, A., & Arikan, Y. (2011). Investigation of the Optimum Duct Geometry for a Passenger Fairy.

Foam Factory. (n.d.). Polyethylene. Retrieved March 25, 2021, from http://www.usafoam.com/closedcellfoam/polyethylene.html

National Aeronautics and Space Administration. (2015, May 5). Shape effects on drag. Retrieved March 25, 2021, from https://www.grc.nasa.gov/www/k-12/airplane/shaped.html

Smithsonian National Air and Space Museum. (n.d.). Pressure Drag. Retrieved March 25, 2021, from https://howthingsfly.si.edu/aerodynamics/pressure-drag

Appendix A

Budget

Component	Vendor	How was this component used?	Cost (USD)
2 Pcs 4ft 1/2 inch Heat Shrink Tubing, 3:1 Adhesive-Lined Large Heat Wire Shrinkable Tube	MILAPEAK	Waterproofing the motors	$0.898
Staples® #1 Size Paper Clips, Nonskid, 1,000/Pack	Staples	To pick up the sunken objects	$0.099
MakerBot PLA Filament, 1.75 mm Diameter, Large Spool, Orange	MakerBot	Material for ROV body	$7.080
Rust-Oleum 249087 Spray Paint Painter's Touch 2X Ultra Cover, 12 Oz, Matte Clear	Rust-Oleum Amazon	Waterproof coating for 3D printed parts	$5.990
TOTAL COST OF SEAPERCH COMPONENTS			$14.067

Appendix B

Fact Sheet

The Angry Ducks

Patriot High School, Nokesville, VA, 20181

STOCK CLASS

4 Years participating in SeaPerch

2 Times at the International SeaPerch Challenge

Our SeaPerch is unique because: (100 words MAX)

Our SeaPerch is unique because of our design approach and many novel elements. We believe it is important to learn from the existing body of scientific knowledge, as well as being innovative, reexamining even the fundamental components of our design, with an emphasis on research and testing to elevate and refine our ideas. This is especially exemplified in the rigorous and exacting design of our thruster mounts, as well as our reimagination of how to waterproof motors. Furthermore, we are proud of the simplicity and versatility of our design, which is streamlined to be ready to tackle any mission efficiently.

SeaPerch Design Overview: (100 words MAX)

Some of the key features of our design include optimization of the frame for hydrodynamic principles with the aim of reducing drag and turbulence. Similarly, our thruster mounts were designed meticulously with the goal of maximizing forward thrust, referencing principles of existing Kort nozzles and hydrodynamics. In addition, the multifaceted recovery device to be able to collect a variety different objects as well as our experimentation with different types of flotation, settling on strategically placed polyethylene, are integral to our design.

Our biggest takeaway this season is: (100 words MAX)

Because of COVID-19, we were in a primarily virtual environment. Consequently, we learned to treasure how research and simulation can elevate our designs. In some sense, because we were forced by the pandemic to take the time and space to step back from our physical design and focus on the concepts and scientific principles, we excelled in the nuances of our design. In the future, we'd like to continue to apply this lesson by continuing to place significant value to research and testing as tools to bring our designs, SeaPerch or otherwise, to the next level.

Appendix C

Engineering Notebook References

Entries | Page 13

ROV COMPONENT ASSEMBLY

With the majority of our design process decided, we began to assemble the components of our ROV. We started with potting and waterproofing of the motors. We assigned Nathaniel to assemble them based on previous experience and finished this in two-meetings times.

The water proofing process involved:
- Wax-proofing/securing the base motors in wound electrical tape
- Solidifying of hot wax around motors, placement of them in canisters
- Capping and sealing of motors, attachment to propellers

Following the water-proofing of the motors, we soldered the leads to the full length of our tether. This allowed us to power the motors remotely and drive the ROV. The circuits, switches, and wiring we used are displayed on the next page

To complete our motor system, we assembled our set of 2-bladed plastic propellers using lock nuts and axels. We then superglued the axel onto the motor and tested them after they dried. All completed motors worked successfully.

Circuits: A device or configuration that allows an electrical current to flow
Switches: Device used for completing and breaking an electrical circuit
Propeller: Mechanical device that propels vehicles through fluids using a shaft and blades

OWNER / DESIGNER | DATE | ☐ UNIT | ☐ PROJECT

WITNESS / TEACHER | DATE | PROPRIETARY INFORMATION

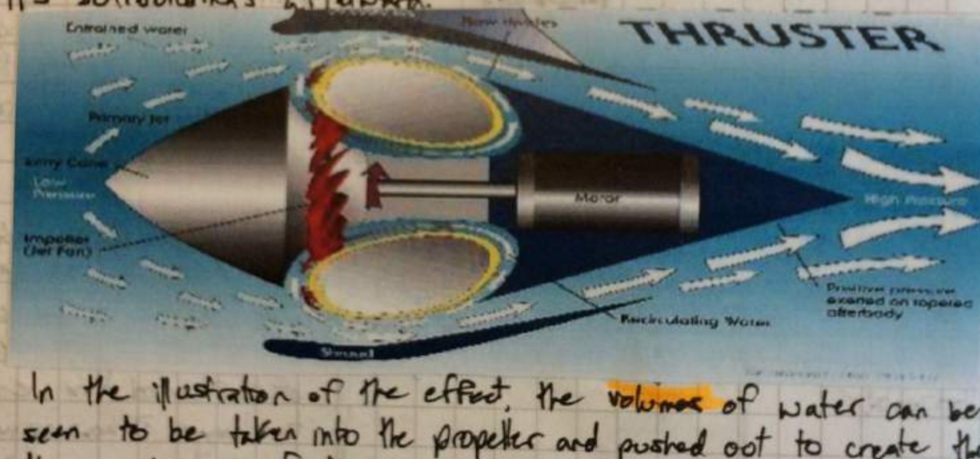
Coanda Effect

Page 16	Entries	

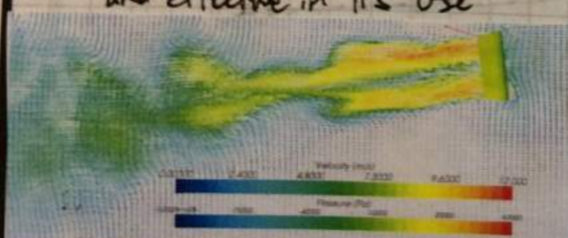
PROPULSION DESIGN CONCEPTS

After assembling our motor system and control box wiring, Xavier and Andrew turned their attention back to researching concepts on propulsion and hydrodynamic theories to improve our ROV

Another useful concept the Andrew found in our research was the applications of the Coanda Effect. In summary, the effect illustrates the phenomena in which passing fluids from propulsion or lift surfaces attach themselves to and then entrains with its surroundings afterward.



In the illustration of the effect, the volumes of water can be seen to be taken into the propeller and pushed out to create thrust. However, because of the thruster layout, the water expelled becomes denser near the center of the motor in a conical fashion. This higher concentration of fluid allows for thrust to be more concentrated and effective in its use



Shown here, one phenomena that Coanda-influenced thrusters could affect is the formation of drag inducing wakes/vortexes in the aft of the thruster. This would improve the overall propulsion output

Volume: Amount of space an object or fluid occupies
Density:

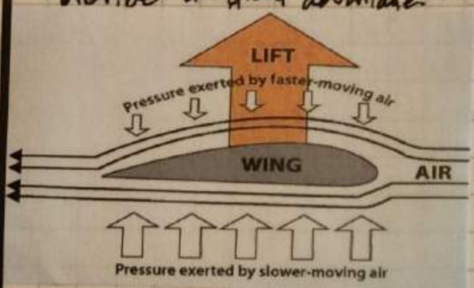
OWNER / DESIGNER	DATE	☐ UNIT	☐ PROJECT
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION	

Bern Principle

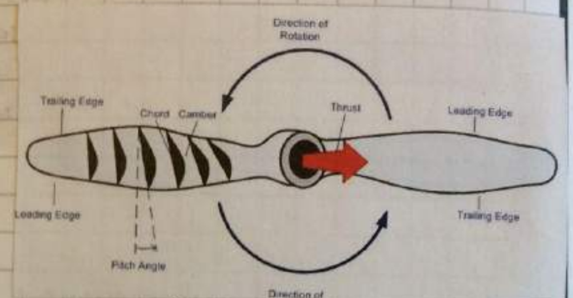
Page 18	Entries	

PROPULSION DESIGN CONCEPTS

In parallel with Xavier, Andrew also continued to reasearching how the Bernoulli's Principle could be incorperated into our design to our advantage. The theories for Bernoulli's principle and the Coanda effect were both similar in their applications to our propulsion system and provide a great advantage.

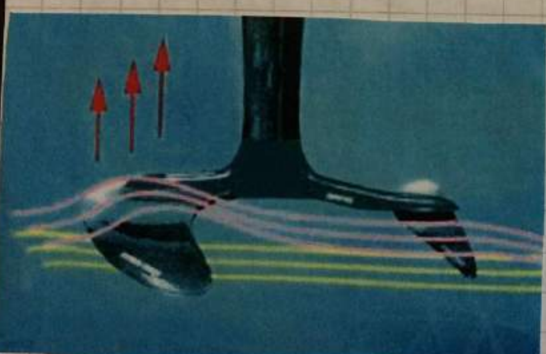


AERIAL WING



PROPELLER

In our research Andrew and Nathaniel found that there were several applications of the Bernoulli's Principle in engineering. Not only was it the primary concept of the aerial wing, but it also was included in propeller design. This principle could also be applied to make our ROV more efficient in the water.



One lesser known use of the principle was its use in hydrofoils. In basic nautical engineering, hydrofoils ~~were~~ are used to provide lift to the entire vessel as it travelled at high speeds. Xavier thought that we might be able to use this in our leading edge surfaces on the ROV.

Hydrofoil: ~~Vanes~~ Vanes fitted under a water vessel to lift it out of the water and reduce its overall drag.

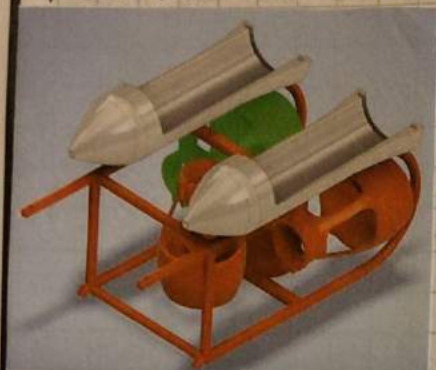
OWNER / DESIGNER	DATE	☐ UNIT	☐ PROJECT
[signature]			
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION	

Page 22

Entries

ROV DESIGN PROCESS...

ROV DESIGN 02



As soon as Xavier was able, he and Andrew worked to achieve a functional design in AutoDesk Inventor. This led to a successful constrainment of the vertical motor shroud to the center support as well as new improved mounts to install the syringes. A slot to install our modular hook was also built behind the central support as planned earlier.

PROBLEMS:

However, upon our attempt to print the ROV, it was discovered that an excessive amount of time and material would be needed to successfully print it. Upon hearing this, Nathaniel recommended reducing the size of the syringe sheaths and removing one of the two entirely to save time and 3D printed ABS material.

ROV DESIGN 03

This problem and its solution was eventually implemented into designing our third test model. ~~Unfortu~~ This included only one syringe sheath as compared to the previous two. Unfortunately, the design was still uncomfortably large and we decided to ditch the sheaths entirely in favor of a minimalistic mount using zip ties to save weight and time printing.

OWNER / DESIGNER [signature]

WITNESS / TEACHER

DATE

DATE

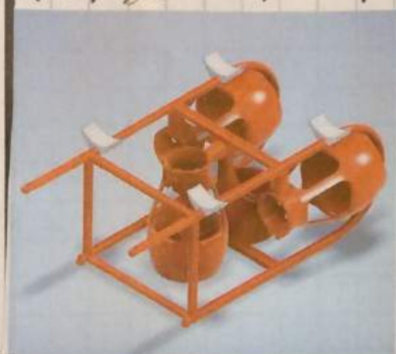
☐ UNIT ☐ PROJECT

PROPRIETARY INFORMATION

Entries	Page 23

ROV DESIGN PROCESS

ROV DESIGN 04

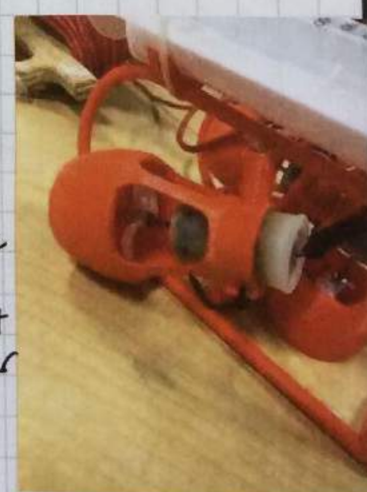


Xavier removed the syringe sheaths located atop the ROV and replaced them with smaller mounts. This left the syringes exposed and would require special sealant techniques to secure properly. To solve this simply, Nathaniel advised simply sealing the fronts of the syringes with removeable electrical monkey dung. Also, this design had improved motor sheaths built to eliminate a motor problem we encountered

APPROVAL AND PRINTING:

Ultimately, this design was approved by our coach and we were successful in printing the design. In total, it took 20 hours and cost us   out of our $25 budget. We quickly removed the 3D printed scaffolding and went to test it out in pod drives. Andrew also began prototyping a final hook design to mount underside our ROV.

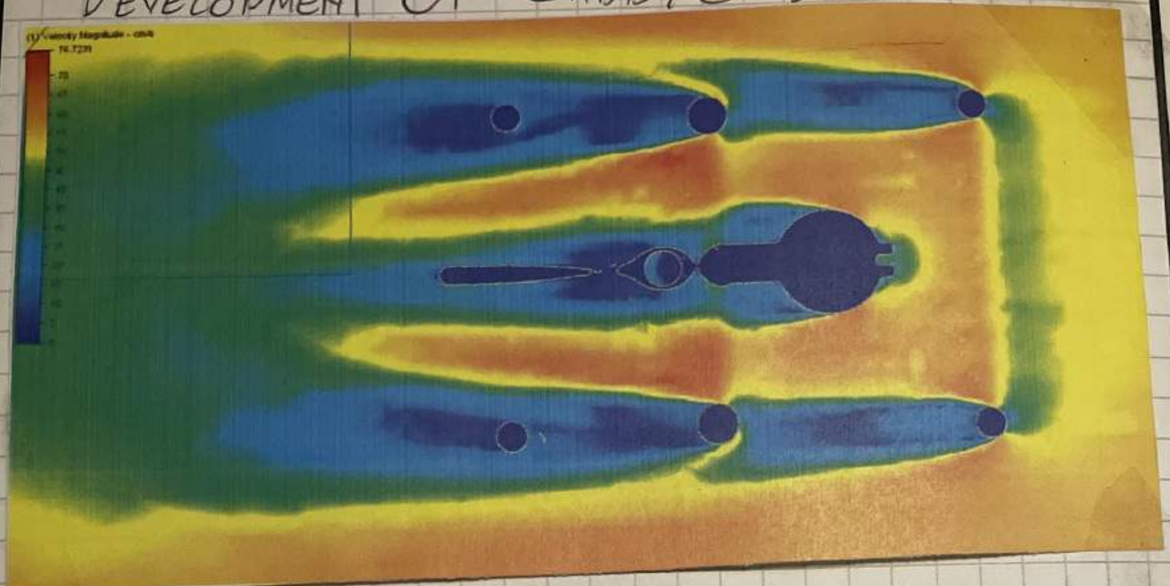
However, after printing, we removed the scaffolding and found that some of the motor sheaths had not been set correctly in the 3D CADD. Fortunately, we were able to fasten them back on using super glue, but we made a note to Xavier to fix the problems with the design on our next design iteration.



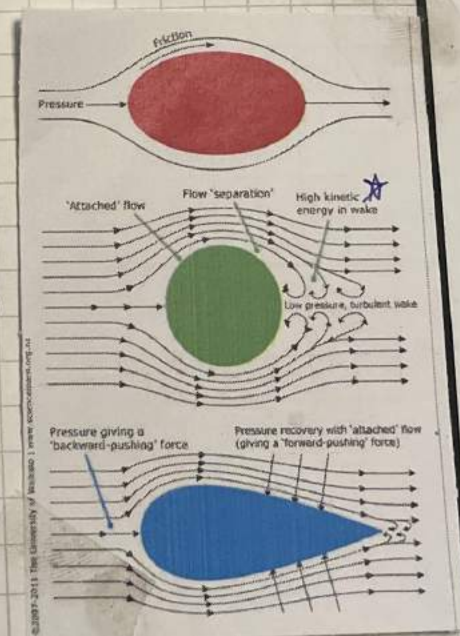
OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Nathaniel Poza		
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION

Page 30 | **Entries**

DEVELOPMENT OF CADD/CFD



This simulation of Cratos opened my eyes to the importance of hydodynamics in our design. These circular supports created an enormous amount of drag and turbulence. This simulation was set to an inlet velocity speed of .60 m/s as it was our target speed. This simulation, like the rest, ~~are~~ have the rov statitonary and the water moving around it. These conditions are ideal for testing the hydrodynamics of the whole design.



Additionally, ~~I~~ I noticed that the leading supports in the above image had the greatest impact on the wake formation.

OWNER / DESIGNER: Xavier Kubancik

DATE

☐ UNIT ☐ PROJECT

WITNESS / TEACHER

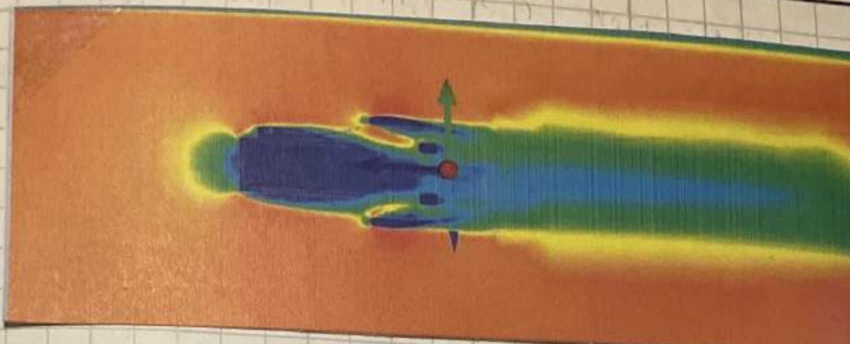
DATE

PROPRIETARY INFORMATION

Entries

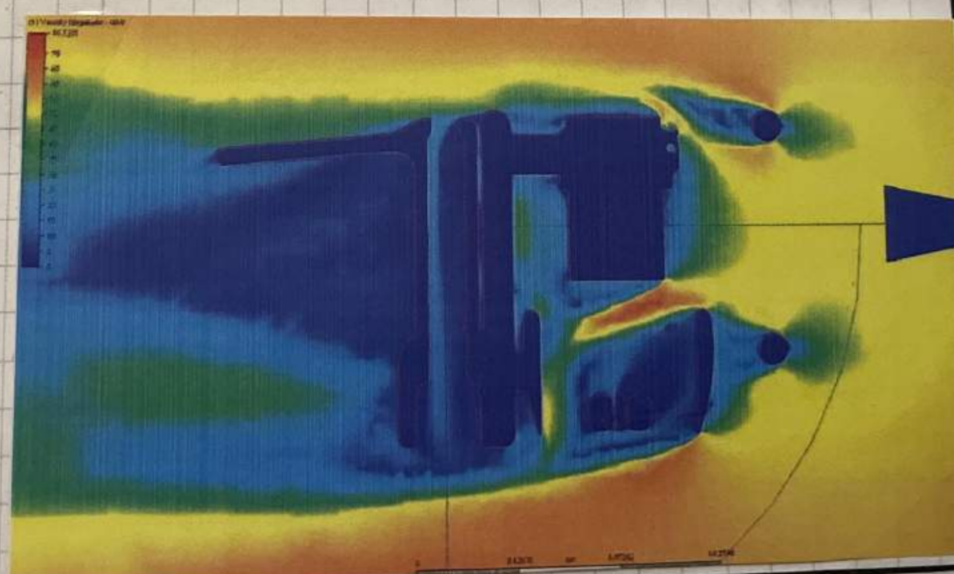
Page 31

CFD (cont.)



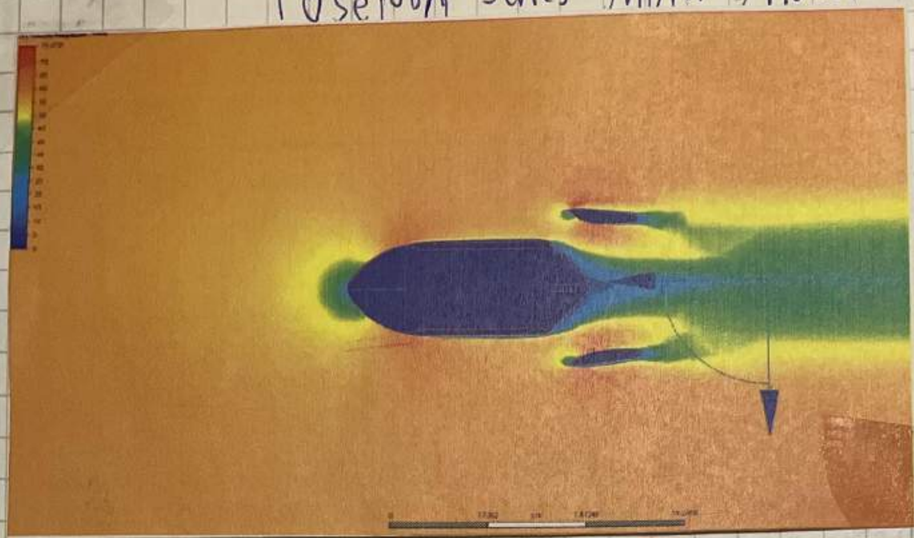
As shown by the picture above, this motor mount is highly inefficient and does not increase the volume of water passing through the propeller. There is a very large stagnation region at the front which causes the wake to be large and an anti-thrust because it is large and flat. Notabely, there is not much water flowing through the inside of the duct so it does not effectively duct water to the propeller.

This is the side view of the vertical motor mount. It poorly manages the flow of water in the horizontal direction. To increase thrust, this must be optomized



OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Xavier Kubancik		
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION

Poseidon Series Motor Mount V3

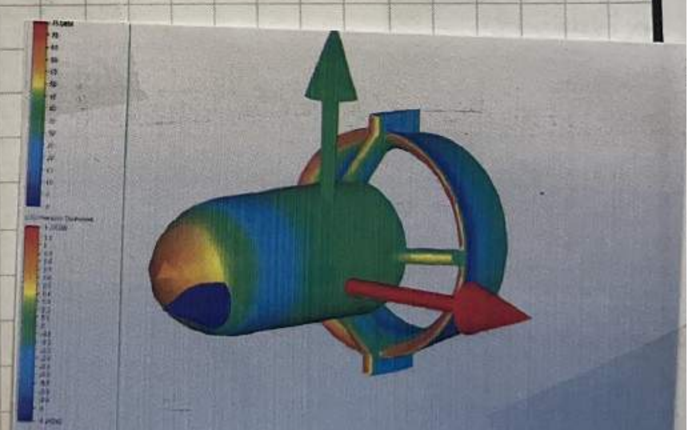


Poseidon V1, V2, and V3 were different designs for how to insert the motor into the mount. After critical analysis, we determined that V3 was the Strongest and ~~Simplest~~ most simple of the 3.

This design is a significant beginning of a new series of motor mounts because it meets my 3 design criteria:

1. Has a nose which reduces stagnation and streamlines flow to propeller
2. Has a duct which increases volume/mass of water flowing into propeller
3. Minimizes flow obstructions, like supports, that are in front of the propeller

While this design is promising, ~~A~~ there are many challenges that lye ahead. Things like the tollerences of the connecting pegs, ~~finding~~ finding the ideal balance between lightness and rigidity.



OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Xavier Kubancik		Poseidon MM V3
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION

Entries Page 33

Zeus I

Zeus is an immense improvement from ~~trates~~ Perseus in every aspect. It is 14 grams lighter while also being more functional. The hook is smaller and lighter so it won't affect the balance as much. This design includes the new ~~perseus~~ poseidon motor mounts which will improve the thrust output of the propellers. The hydrodynamics of this design are far superior to perseus since it was designed with the aid of CFD testing.

☐ UNIT ☐ PROJECT

DATE

OWNER / DESIGNER Xavier Kubanek

DATE

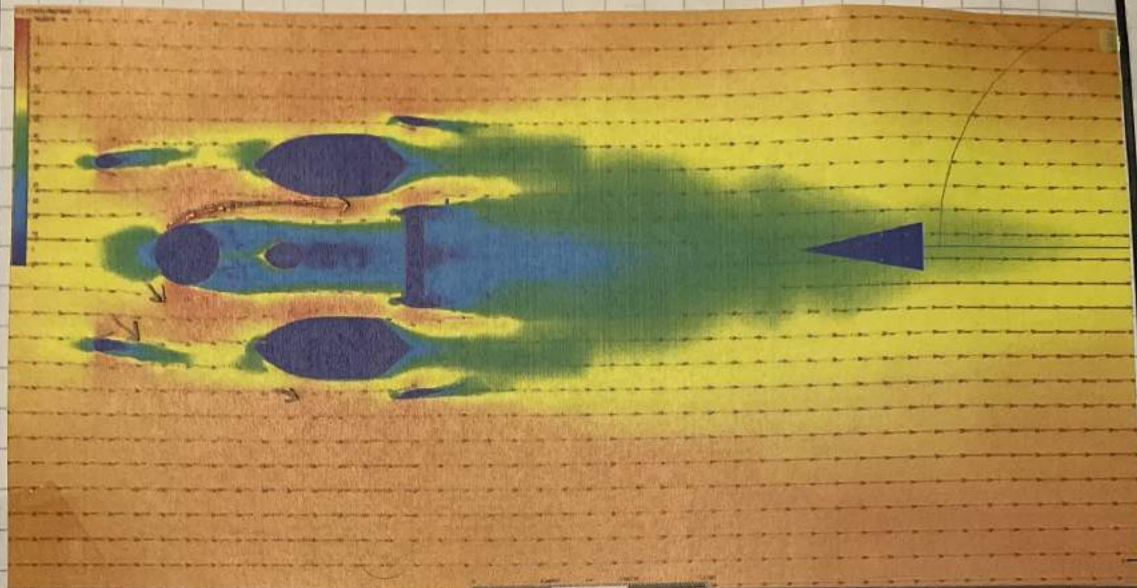
WITNESS / TEACHER

PROPRIETARY INFORMATION

Page 34

Entries

Zeus I CFD test



This design is a massive improvement over perseus because the wake has been significantly reduced and the flow of water is streamlined to reduce low pressure, turbulent regions that cause drag.

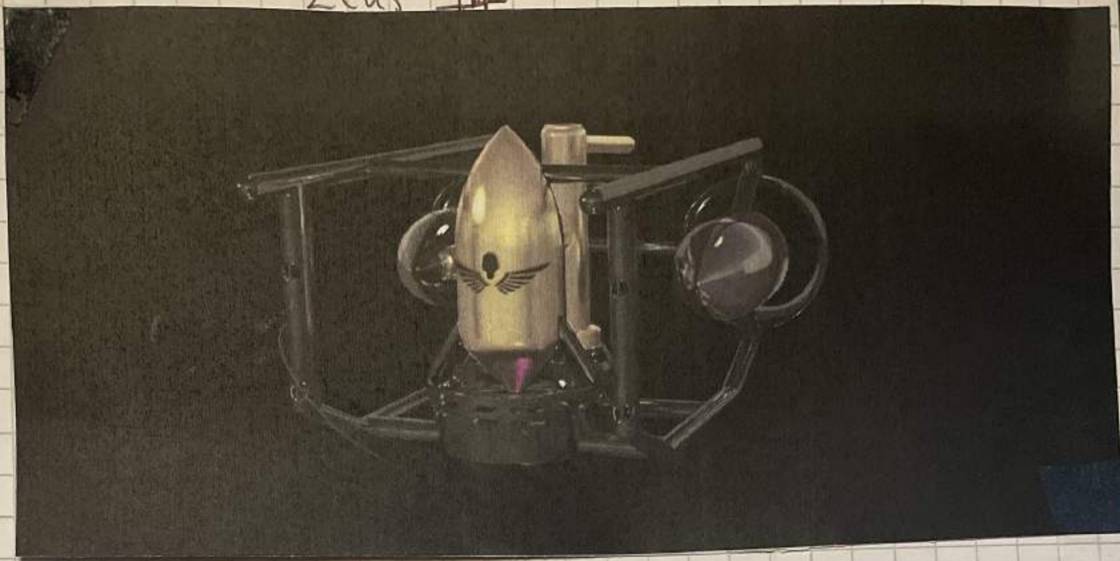
Noteably, there is a large, low pressure wake behind the verticle motor because of its circular shape. This is problematic because this drastically affects the flow of water on the outside of the ducts, as shown by the added arrows I drew. This will have to be reduced to further increase the ROV's speed.

This unique aspect of our design has its upsides. Because of the flow separation behind the verticle motor mount, ~~there is~~ I placed the horizontal motor mounts in a way that takes advantage of this high velocity stream of water.

OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Xavier Kubancik		
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION

Entries

Zeus III



Zeus III is our next iteration which, like its predessor, is a siginificant improvement over the last design. It's 31.2% lighter and 23.1% faster. The top speed is .80 m/s. There are new features like insertion points for the paper clips we will use to recover sunken objects. The CFD tests show similar, but improved, results.

The biggest change to this design is the inclusion of shrink wrapped motors. They are smaller and lighter so we were able to reduce the size of the motor mounts significantly. This increases the area that water can flow through to the propeller.

My favorite part of this design is the vents on the front of the verticle motor mount that passively create downforce. This will be discussed in detail in a later page

OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Xavier Kubancik		
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION

Passive Downforce System

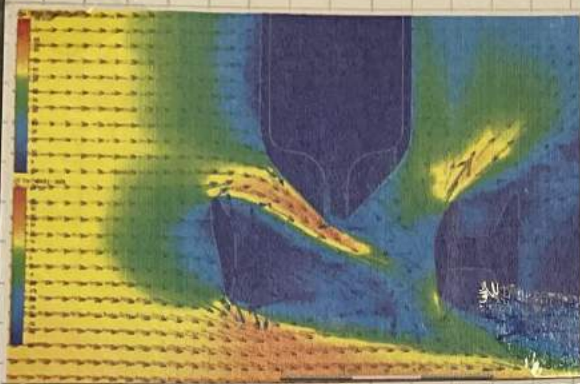


Fig 1 Zeus

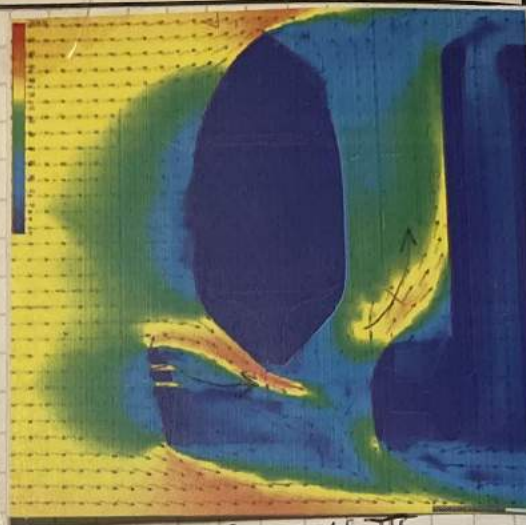
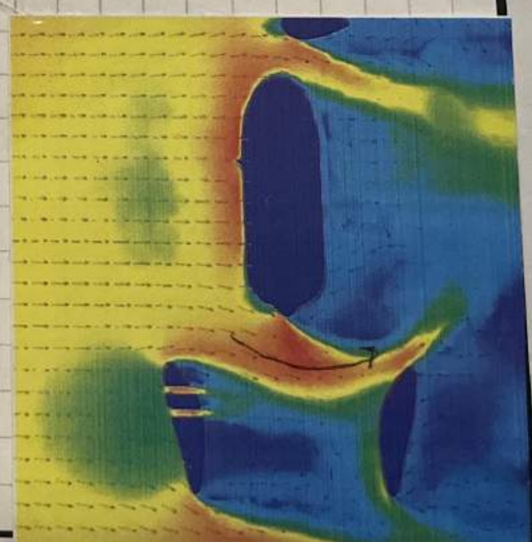


Fig 2 Zeus II

I noticed that the verticle motor mount for Zeus ~~[struck]~~ has a stagnation region in front of the Vert. mm duct, I also noticed that some of the flow of water was redirected up ward because the duct looks like a wing turned 90°. Zeus had a problem of pourposing up because ~~[struck]~~ the weight is biased towards the rear. I hypothesised that if I increased the flow of water in this region, then a Significant downforce could be created that would eliminate pourposing.

To increase the flow in this area, I added vents to the front of the ROV, After doing this, The upwards flow of water increased dramatically, which ~~[struck]~~ proves my hypothesis for creating down force correct as shown in Fig 2



Intrestingly, this change increased the speed of the ROV because it ~~[struck]~~ increased the pressure behind the vertical motor mount. This effectively means that the wake was reduced, increasing the top speed

OWNER / DESIGNER: Xavier Kubancik

DATE:

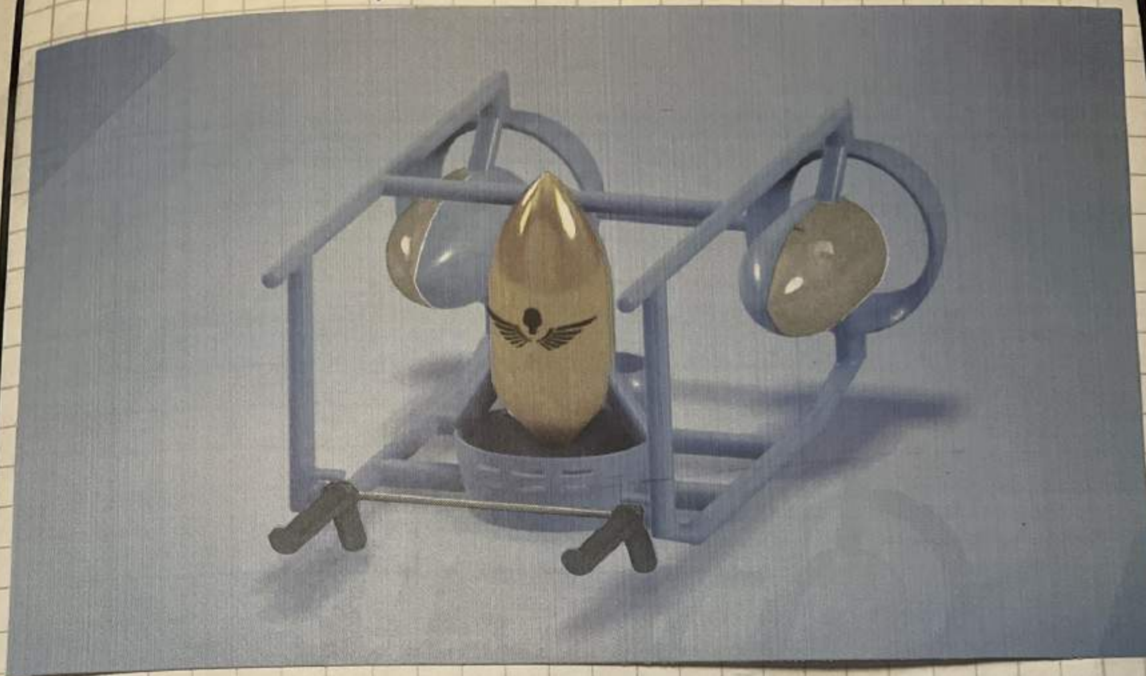
☐ UNIT ☐ PROJECT

WITNESS / TEACHER:

DATE:

PROPRIETARY INFORMATION

Kronos



This is our final and greatest design yet. The frame is bigger than Zeus III but it weigs 1g less since I reduced the diameter of the frame from .3 to .24 in. The frame is longer to increase how easy it is to score objects using the front levers.

The front levers replace the paper clips because they have the same properity of elasticity since they are tensioned using rubber bands. These are better because they have a downward facing part, that when pushed against the hoola-hoop, it will release the ~~floating~~ object. This will make scoring floating cylindrical objects easier.

The poseidon MMV4 were replaced with the V5 MM. because they have a parabolic shaped hose and my duct design that is better than the previous duct design.

DATE

☐ UNIT ☐ PROJECT

OWNER / DESIGNER
Xavier Kubancik

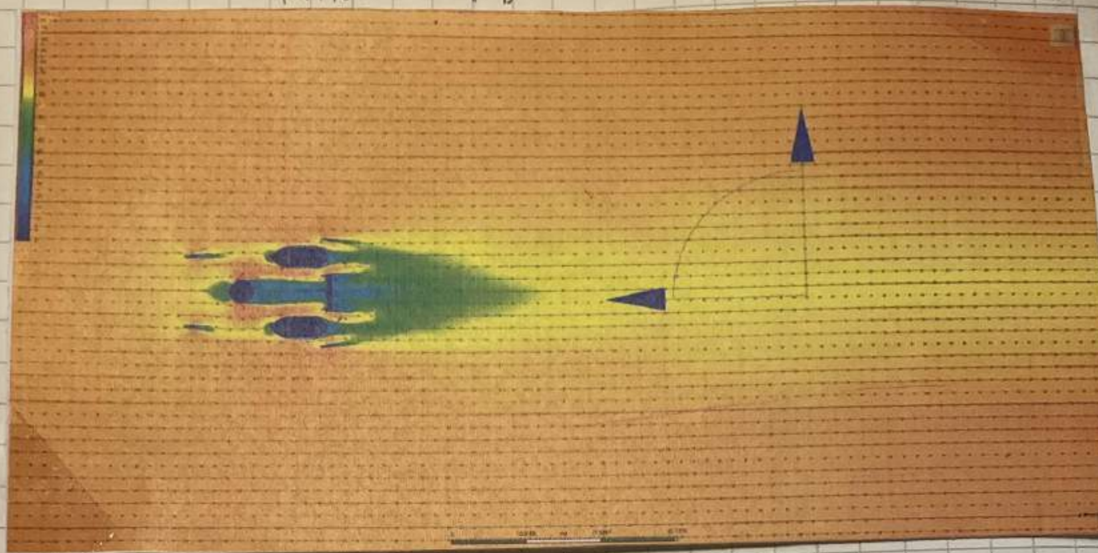
DATE

WITNESS / TEACHER

PROPRIETARY INFORMATION

Page 40 | **Entries**

Kronos CFD



In order to increase the speed even further, I more meticulously used CFD and increased my tolerance for what I considered acceptable. As a result, the wake of this design is vastly smaller to the previous design.

The problem of the low pressure area behind the verticle motor mount was ~~increased~~ decreased by reducing the diameter of the verticle motor and increasing the size of the vent holes. As a result, the ~~motors~~ propellers recieve increased volume and mass of water.

All of these changes allowed our ROV to move at its fastest top speed of .89 m/s, which allows it to complete the 12.5 m Speed Challenge in about 14 seconds

OWNER / DESIGNER	DATE	☐ UNIT ☐ PROJECT
Xavier Kubancik		
WITNESS / TEACHER	DATE	PROPRIETARY INFORMATION