1. ABSTRACT

This Technical Design Report highlights the Engineering Design Process (EDP) Team Kraken used to create the Kraken Remotely Operated Vehicle (ROV) and the successful design features. This report will review the challenge course, obstacle course, new mini course tasks and how they influenced the team's engineering design approach. Analysis of experimental results included in the report demonstrate how detailed testing was used to decide on the final design. Additionally, the report describes the team's reflection of the SeaPerch journey to this point and future plans for the Team Kraken ROV design and team members. The Kraken ROV is extremely unique and stands out in the SeaPerch community because of the following design features:

- **Multipurpose Frame Design:** The frame allows for easy attachment of motors but is also hollow to allow stowing of the gripper fingers for the obstacle course to reduce drag and overall ROV size.
- **Ultralight Design:** The frame is hollow and weighs 1.06 ounces to provide maximum thrust to mass ratio (Wing, Charlie, 2004, 2007) for peak ROV speed.
- **Adjustable Buoyancy/Trim:** Test tubes, travel bottles, and 3D printed buoyancy that can be interchanged are used to adjust buoyancy between positive, negative, or neutral. The buoyancy bottles also move easily forward or backwards to adjust the ROVs trim (Bowditch N. 2002). This enables quick adjustments based on the complex tasks the course contains.
- **Gripper:** The ROV gripper is used to lock floating tools place and grab the vault gate.
- **Innovative Parts:** The ROV under mount hook is carved from plastic cutting board and used for grabbing and transporting the batteries. The innovative design enables it to be folded and stowed inside the frame to shorten the ROV and make it more maneuverable through the obstacle course.
- **Brightly Colored:** A variety of bright colors are used on the ROV to easily identify components and orientation underwater.

2. TASK OVERVIEW

The pool mission consists of four tasks. By following the EDP, Team Kraken is able to successfully navigate the challenges in the time limits required to achieve maximum points on all tasks.

- **Battery Panel Access-** Requires turning a lever arm and pulling open a panel to reach the batteries. It was quickly discovered that the mini servo didn't have much torque, therefore the hoop attached to the lever would slip out of the gripper. Teeth were added to the gripper hooks to allow a more secure hold on the hoop.
- **Disconnect Power Cables-** Requires pulling ropes attached to the batteries with magnets until they disconnect. The gripper was versatile already, allowing the ROV to disconnect both cables at once.
- **Battery Replacement-** Requires the ROV to pick up and transport the deactivated batteries and replace them with active batteries. Because of the wide circumference of the PVC pipe, closing the gripper around the batteries was difficult. Carrying the heavy batteries in the front of the ROV also caused an uneven distribution of weight making it difficult to drive straight. A bottom hook attachment was added allowing the weight to be carried in the middle of the ROV.
- **Tool Transport-** Requires grabbing, transporting, and placing buoyant tools on a small tool caddy. The main problem was that the tools would constantly slip into the back of the grippers causing the rope on the tools to get tangled with parts of the ROV. In response to this, a fishing line was added on the grippers preventing the tools from slipping back any further. The ROV was also too responsive, it turned left and right dramatically making it difficult to line the ROV up when placing the tools. A fin was added to the back of the vehicle creating drag when turning.
- **Obstacle Course-** Requires diving, surfacing, and travelling through five vertical and horizontal hoops in the least time possible. Team Kraken's enhanced hydrodynamics (Lucas J., 2014), motor improvements, and ultra-light frame resulted in an obstacle course run of 32 seconds.

3. DESIGN APPROACH

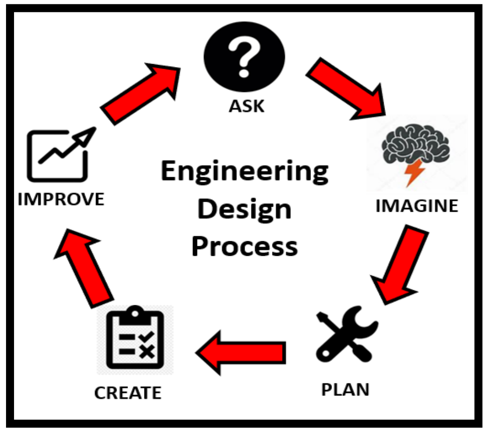


Fig. 1 - EDP Diagram

Team Kraken consistently approaches the EDP with detailed techniques focused on innovation for each design iteration.

ASK- The first step of the EDP is to survey tasks and ask what improvements are needed to complete the course most efficiently. Team Kraken identifies the following questions with each design iteration: How can the ROV's speed be maximized? How can buoyancy (OpenStax College, 2013) be adjusted for different situations? How can items be lifted and transported?

IMAGINE-Team Kraken brainstorms ways to solve the questions from the first stage of the EDP with these priorities:

1) Improve attachments for the mission course.
2) Reduce frame size and drag (Wing, Charlie, 2004, 2007).
3) Increase motor Revolutions Per Minute (RPMs) (Kemp, Peter, 2005).

PLAN- Team Kraken creates a plan for each design feature imagined. The plans include drawings, materials, building techniques and testing methods.

CREATE- After planning the improvements, Team Kraken transitions into a building/testing phase for each iteration. The team tests each improvement so informed design decisions can be made.

IMPROVE- Test results for design iterations are analyzed and final decisions are made. Sometimes this involves considering design tradeoffs such as the additional capability a servo provides for grabbing and locking floating tools vs the additional weight added to the ROV.

ROV DESIGN ITERATIONS

KRAKEN 1.0	**Frame Weight:** 25.0 oz	**Speed:** 1.20 FT/SEC

The standard SeaPerch frame was built to establish a baseline. Because the frame was so stable, Team Kraken decided to base the next design on it but make it smaller.
Pros: Very stable and easy to drive. **Cons:** Slow, sluggish maneuverability (Moore S.W., 2010).

KRAKEN 2.0	**Frame Weight:** 8.17 oz	**Speed:** 1.34 FT/SEC

Mirrored the SeaPerch frame but built using Chlorinated Poly Vinyl Chloride (CPVC) and Cross-Linked Polyethylene (PEX) pipe to reduce frame size. This design verified speed increases as size and weight are reduced. It was stable and maneuverable, but the team decided to redesign to test how improving hydrodynamics (Lucas J., 2014) effects ROV performance.
Pros: Easy to navigate hoops course. **Cons:** Dives slowly.

Fig. 2 - Kraken 2.0

KRAKEN 3.0	**Frame Weight:** 5.64 oz	**Speed:** 1.66 FT/SEC

Built with a pointed front, this design iteration validated that improved hydrodynamics increases speed. However, the ROV was hard to control when diving and surfacing. The team believed the control issue was based on motor location and center of buoyancy so the ROV was redesigned to adjust these factors.
Pros: Increased speed. **Cons:** Difficult to control.

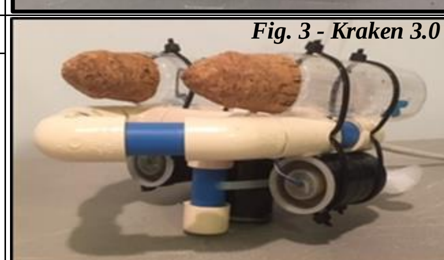


Fig. 3 - Kraken 3.0

KRAKEN 4.0	**Frame Weight:** 4.49 oz	**Speed:** 1.76 FT/SEC

Shortened the ROV frame and moved the vertical motor forward. This design justified that reducing size and drag increases speed and motor location dramatically affects ROV control.
Pros: Increased stability (Wing, Charlie, 2004, 2007).
Cons: Overall performance and design limited by materials.

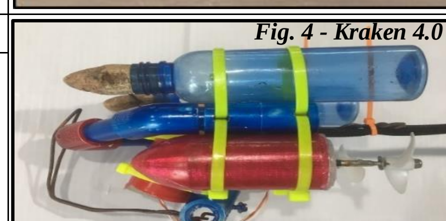
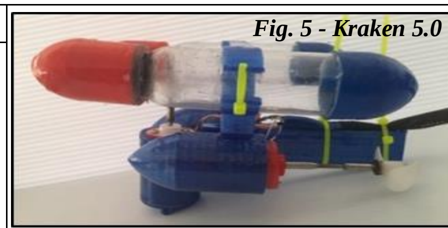
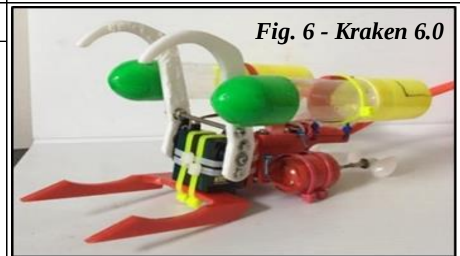
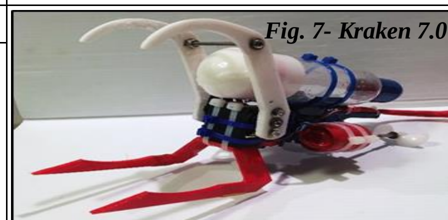
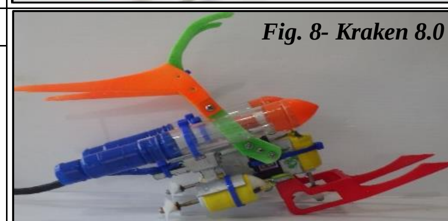
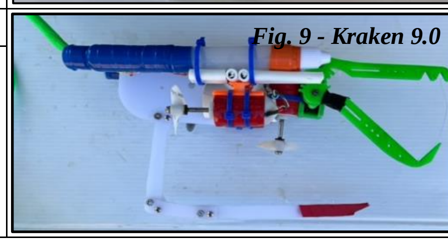


Fig. 4 - Kraken 4.0

<table>
<tr><td>KRAKEN 5.0</td><td>Frame Weight: 3.0 oz</td><td>Speed: 1.82 FT/SEC</td><td rowspan="2">
Fig. 5 - Kraken 5.0</td></tr>
<tr><td colspan="3">3D printed the ROV frame to reduce ROV weight. This design showed symmetry improved ROV stability and control (Wing, Charlie, 2004, 2007). 3D printing provided flexibility, but the six-hour print times caused delays with redesigns or repairs.
Pros: Increased stability. Cons: Long print times.</td></tr>
<tr><td>KRAKEN 6.0</td><td>Frame Weight: 1.70 oz</td><td>Speed: 2.04 FT/SEC</td><td rowspan="2">
Fig. 6 - Kraken 6.0</td></tr>
<tr><td colspan="3">A 3-part frame design to reduce 3D print times. This design was called the Modular Frame Vehicle (MFV) because it is made of small interchangeable parts. This feature reduced print time by more than 50% for redesign and repairs. The ROV performed well but when the servo gripper was added, it reduced hydrodynamics.
Pros: Quick 3D printing times. Cons: Weak frame strength.</td></tr>
<tr><td>KRAKEN 7.0</td><td>Frame Weight: 1.34 oz</td><td>Speed: 2.20 FT/SEC</td><td rowspan="2">
Fig. 7- Kraken 7.0</td></tr>
<tr><td colspan="3">A MFV frame modified from two bottles to one to reduce drag. The vertical motor was also inverted to face down, which provided more thrust to pick up items and reduced surface ripple. Although the ROV was fast, it was redesigned to improve ROV stability
Pros: Improved lifting power. Cons: Poor stability on surface.</td></tr>
<tr><td>KRAKEN 8.0</td><td>Frame Weight: 1.17 oz</td><td>Speed: 2.78 FT/SEC</td><td rowspan="2">
Fig. 8- Kraken 8.0</td></tr>
<tr><td colspan="3">A two bottle MFV design with the servo behind the vertical motor to further improve lifting capability and hydrodynamics. The frame enabled the servo to be stowed during the obstacle course to reduce drag and a had bulldozer attachment for 2021 SeaPerch challenges.
Pros: Increased stability. Cons: Heavy servo.</td></tr>
<tr><td>KRAKEN 9.0</td><td>Frame Weight: 1.06 oz</td><td>Speed: 2.53 FT/SEC</td><td rowspan="2">
Fig. 9 - Kraken 9.0</td></tr>
<tr><td colspan="3">A one-inch PVC T-joint with ¼ inch PEX pipe was used to create a versatile lightweight frame designed to be in compliance with new stock class rules. The servo was replaced by a micro servo to reduce the drag and also the amount of bouyancy required for the ROV.
Pros: Stowable gripper and hook. Cons: Reduced servo torque.</td></tr>
</table>

FINAL DESIGN DISCUSSION/FEATURES The new frame uses a smaller micro servo in the front of the vertical motor to reduce drag for the obstacle course. Adding a servo gripper was the most difficult design feature on the ROV. Despite the added weight (0.42 oz) and difficulty waterproofing, the increased capability provided makes it necessary. Additionally, having the servo controlled by the driver enables the line tender to focus on helping guide the driver and improves Team Kraken's poolside teamwork and communication. All the improvements combine to make Team Kraken's most innovative ROV. Additional unique features include:

Adjustable Buoyancy
Enables quick change of ROV pitch/buoyancy

Micro Servo Gripper
Ensures floating tools don't float away

Improved Motors
Doubled motor wires reduce resistance/increase RPMs

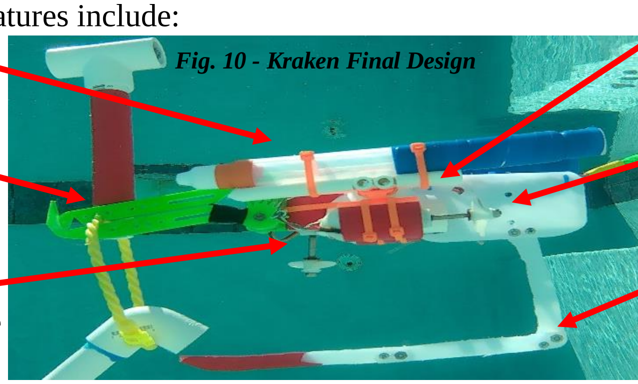


Fig. 10 - Kraken Final Design

Upgraded Waterproofing
3D printed cap and resin sealing prolongs motor life

Counter Rotating Props
Reduces torque steer and helps ROV drive straight

Folding Hook
Enables stowing of hook to reduce ROV height

4. EXPERIMENTAL RESULTS

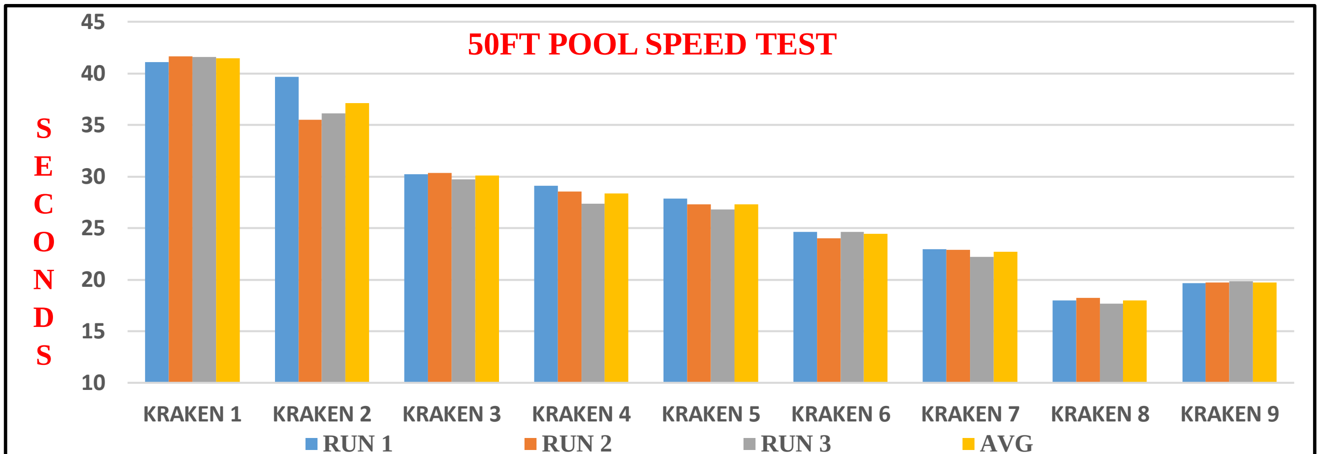
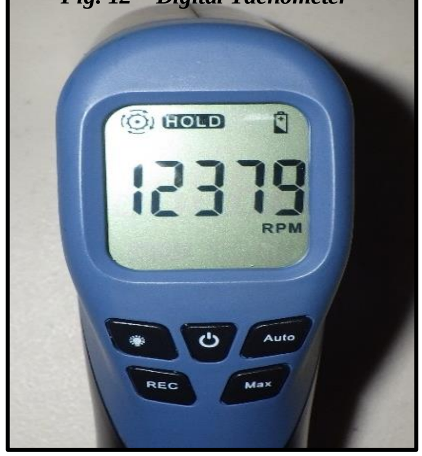


Fig. 11 - 50FT Pool Speed Test

Speed Test: For Team Kraken the most important ROV design factor is speed. The team conducts in-water testing of each ROV with three runs of 50 feet for each ROV design. Then the team calculates each ROVs speed in FT/SEC. Figure 11 demonstrates as the ROV size/weight is reduced, thrust to mass ratio and ROV speed increases. Speed testing is key in determining the Kraken ROV final design.

RPM Test: RPMs establish a good measure of motor performance, and the team uses a digital tachometer to measure RPMs of motors. Team Kraken's observations include:

Fig. 12 – Digital Tachometer



- Higher battery voltage produces higher RPMs. The team standard is to test and only use batteries above 13 Volts.
- RPMs range from 10,500 to 11,600 on new motors. Having right and left motors with equal RPMs help the ROV drive straight.
- Decreasing electrical resistance increases current (Moore S.W., 2010) to the motor. Team Kraken utilizes solid CAT 5 wire instead of stranded, doubles up CAT 5 wires from the RJ-45 connector to the positive motor terminals and reduces cable length from 50ft to 35ft. These modifications, on average, reduce resistance from 1.8 Ohms to 1.2 Ohms and increase RPMs from 11,500 to 12,300.

Drag Test: With a dedicated focus on improving hydrodynamics, the team tests ROV drag. After completing a drag test (Moore S.W., 2010) using spring scales for ROV design iterations the team confirms that forward surface area on the ROV directly affects ROV drag and correlates to ROV speed. Utilizing the EDP Team Kraken creates thinner ROV designs, reduces use of zip ties, and curves forward facing surface areas on all design reiterations. Additionally, to further evaluate the effect of drag compared to ROV speed, the team measures forward-facing surface area. The standard SeaPerch ROV is 27.85in² and the final design Kraken 9 is 8.54in². Overall surface area was reduced by 69.4% and speed increased by 110.8%. As surface area is reduced, speed increases. However, motor improvements on design iterations make it impossible to calculate an accurate ratio of drag vs speed increase.

Prop Test: A 50-foot pool speed test of propellors is conducted to analyze performance of various propellers. Testing includes the standard SeaPerch, 3 bladed, 4 bladed, and 3D printed propellers. Testing evaluation demonstrates the standard SeaPerch propeller provides maximum speed.

Functionality Test: To verify ROV functionality a full mockup of the mission course including the tool caddy, batteries and vault is used. The course provides the ability to test the servo gripper, hook, and redesign as necessary to improve the ROVs ability to complete all tasks as quickly as possible.

5. REFLECTION AND NEXT STEPS

The EDP steps below are key to the innovations applied to the Kraken ROV:

- **Ask-** First, the course was built and tested with each ROV. This enables the team to take note of all the requirements that each design is not meeting. Once the team identifies imperfections, the following questions are raised: How can ROV speed be improved? How can motor performance be increased? How are challenges navigated?
- **Imagine-** When imagining and brainstorming, Team Kraken's coaches challenged them to use different materials and to not rule out any idea until it was attempted. This led to innovations in 3D design, motor improvements, and the creation of the Kraken gripper.
- **Plan-** The team had to research and plan for materials, timelines, and new innovations. This EDP step helps the team be more prepared.
- **Create-** Building and constructing each ROV and its parts is the most time-consuming step. This step led to creation of the MFV which decreases the ROV manufacturing, repairs, and redesign time.
- **Improve-** According to Team Kraken, the most important part of the EDP is to improve. Nine different ROV design iterations were constructed and each time the team assessed how they worked and ways they could be improved.

In the end, the EDP led Team Kraken to success and continues to help as they push towards their goals.

Teams Future Plans:

- Team Kraken's lead designer Paul Shanklin will graduate high school this year and transition to UNF to pursue a degree in Cyber Security. Kara Shanklin, the teams technical reporter and driver is the last remaining member of team Kraken and intends to focus on early college and other clubs.
- Both Paul and Kara intend on returning to Mayport Middle School club to teach everything the team has learned to new club members so the Kraken legacy can continue.
- Team Kraken intends on researching RoboSub and SeaMate and possibly compete next year.

ROV Future Plans:

- Team Kraken built a capable open class ROV with 4 motors (vertical, right, left, booster). It has a wireless PS2 controller but after years of driving with simple push buttons and switches the driver finds the PS2 controller more difficult to for driving. The team has started designing their own Printed Circuit Board (PCB) to create a controller for 4 motors.
- Team Kraken open class ROV uses an underwater camera and display poolside to help the driver in identifying the ROVs proximity to objects prior to grabbing them. The screen is small and team Kraken is researching how to get the camera to display on their phones so they can use a VR headset display for improved display and underwater awareness.

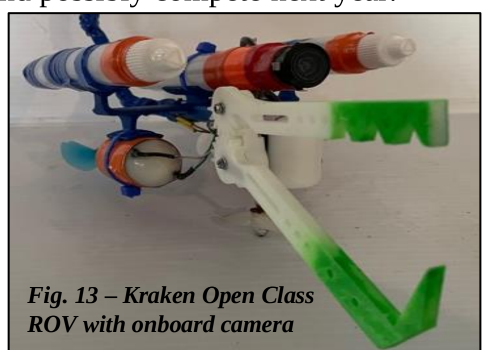


Fig. 13 – Kraken Open Class ROV with onboard camera

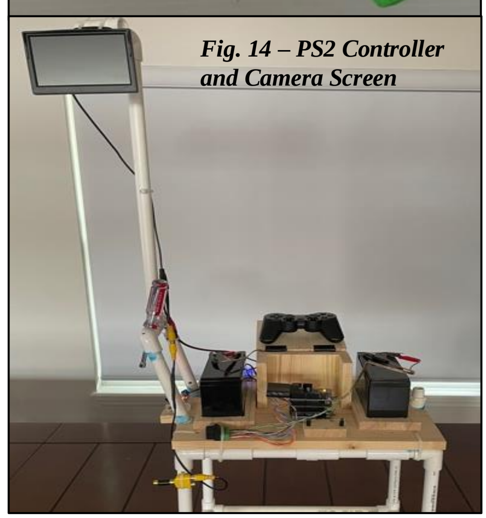


Fig. 14 – PS2 Controller and Camera Screen

Lessons Learned: Team Kraken learned many valuable lessons and it has been a lot of hard work over many years. The most valuable lesson learned is that failure is the best teacher. An untimely propellor detachment during 2019 internationals taught them that failures happen but true engineers can reduce them. Most importantly, failing to reach their goal at Internationals taught them that ROVs can always be improved, and success comes with hard work.

6. ACKNOWLEDGEMENTS

We would like to thank everybody who helped us get to where we are today. We are truly fortunate to be able to compete in this challenge and have this experience. First, we want to say thank you to all our amazing coaches. They helped us get through all the challenges that we faced through the years and taught us a lot about robotics. Mr. Hudson, who started the Mayport robotics club, has helped supply us with new materials to try for our ROV. He also showed us many things that helped us when designing our ROV. Another coach that helped us a lot along the way was our dad who helped us stay organized, helped with supplies, and really pushed us to get the work done. Mr. Felice is our final coach and our ROV would be completely different without him. Mr. Felice taught us 3D design and printing. Thanks again to all our amazing coaches, we don't know where we would be without them.

Sponsors are also super important to our team. Without them we would not have been able to afford materials and transportation, we literally would not have been able to be here without them. Our sponsors are TIAA bank, Worlds Finest Chocolate, STEM2HUB, SERMC, Embry Riddle and parents who donated to the club. With the help of our sponsors, we were able to travel and compete in multiple regionals and International SeaPerch competitions. Thanks to all our sponsors and everyone who helped donate to our club.

Last, but certainly not least, we would like to thank all the parents of the club. They help with transportation, materials, motivation, and organization. That is why parents are essential to this club, so big thanks to our parents, sponsors, and coaches for all your contributions to our team.

7. REFERENCES

Bowditch N. (2002) The American Practical Navigator: An Epitome of Navigation, Maryland B., National Imagery and Mapping Agency

I.C.B. Dear. Kemp, Peter. The Oxford Companion to Ships and the Sea., Oxford University Press Inc. 2005

Lucas J. (2014, Aug.20). What is Fluid Dynamics? Retrieved From: www.livescience.com/amp/47446-fluid-dynamics.html.

Moore S.W., Bohm H., Jensen V. (2010) Underwater Robotics: Science, Design & Fabrication, Montgomery C.A., Marine Advanced Technology Education (MATE) Center

OpenStax College, College Physics. (2013, September 17). Archimedes' Principle. Retrieved From: https://cnx.org/contents/geIysFJF@14/Archimedes-Principle

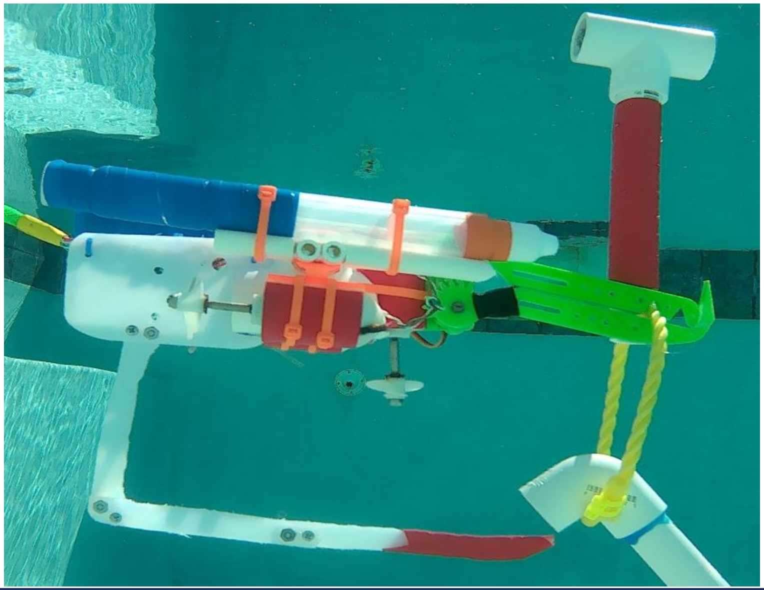
Wing, Charlie. How Boat Things Work An Illustrated Guide, 2004-2007

APPENDIX A: Budget

Component	Vendor	How was component used?	Cost (in USD)
¼ Inch PEX Piping (1FT)	Home Depot	ROV Frame	$0.45
3/4 Inch PVC T Joint	Lowes	ROV Frame	$0.82
¼ Inch Wood Dowels 12 inch (1)	Amazon	ROV Frame	$0.17
3D Motor Caps (6-1 Gram each)	Self-designed/printed	Motor Waterproofing	$0.30
3D Gripper Fingers (2-5 Grams each)	Self-designed/printed	Gripper Fingers	$0.50
3D Horizontal Motor Holders (2-3 Grams each)	Self-designed/printed	Motor Holder	$0.30
3D Bottle Buoyancy (2-2 Grams each)	Self-designed/printed	Buoyancy	$0.20
3D Cable Buoyancy (4-4 Grams each)	Self-designed/printed	Buoyancy	$0.80
3D Servo Holder Part 1 (1-4 Grams)	Self-designed/printed	Servo Mount	$0.20
3D Servo Holder Part 2 (1-2 Grams)	Self-designed/printed	Servo Mount	$0.10
3D Button Holder (1-1 Gram)	Self-designed/printed	Button Mount Controller	$0.05
3D Printed SeaPerch propellor (CW) (1-1 Gram)	Self-designed/printed	Counter Rotating Propellor	$0.05
Servo (MG90S) (1)	Ebay	Gripper Actuator	$1.89
Servo Controller (1)	Aliexpress	Servo Operation	$3.28
4 Pack Battery Holder (1)	Amazon	Servo Power	$2.96
1.5V Batteries (4)	Amazon	Servo Power	$0.84
SPDT Button	Amazon	Servo Operation	$1.10
Servo Wiring (CAT 5 – 40 Feet)	Amazon	Servo Power	$2.40
Gripper Fishing Line	Amazon	Prevent Course Tangle	$0.10
30ml Plastic Bottles (2)	Amazon	ROV Buoyancy	$0.72
15ml Plastic Bottles with Cap (2)	Amazon	ROV Buoyancy	$1.16
Cable Sheathing (35 Feet)	Amazon	Cable Collection	$3.15
Heat shrink (9 pcs)	Amazon	Wire Waterproofing	$0.17
Lube Compress Packing Seal	Amazon	Motor Waterproofing	$0.30
SLA Resin	Amazon	Motor Waterproofing	$0.30
Marine Grease	Amazon	Motor Waterproofing	$0.09
4-40 Screws/Nuts (6 Screws, 6 Nuts)	Amazon	Hook Hardware	$0.60
Plastic Cutting Board (<50% used)	Dollar Store	Hook	$0.63
TOTAL COST OF SEAPERCH COMPONENTS			$23.63

Team Kraken

Sandalwood High School- Jacksonville, FL



HS-STOCK

4 Years participating in SeaPerch

2 Times at the International SeaPerch Challenge

Our SeaPerch is unique because: (100 words MAX)

Adjustable Buoyancy/Trim: Buoyancy moves easily forward/backwards to adjust ROV's trim. Hidden buoyancy enables instant neutral, negative or positive buoyancy.
Ultralight Design: Weighs only 1.06 oz to improve thrust to mass ratio.
Gripper: Servo gripper to lock floating tools in place.
Innovative Parts: Capable of being reoriented or stowed to reduce ROV size.
Color: Bright design allows us to identify which direction the bot is facing.
Expandable Sheathing: Produces less kinking and more flexibility.
Cable Buoyancy: Buoys on the cable allow for less weight affecting the ROV.

SeaPerch Design Overview: (100 words MAX)

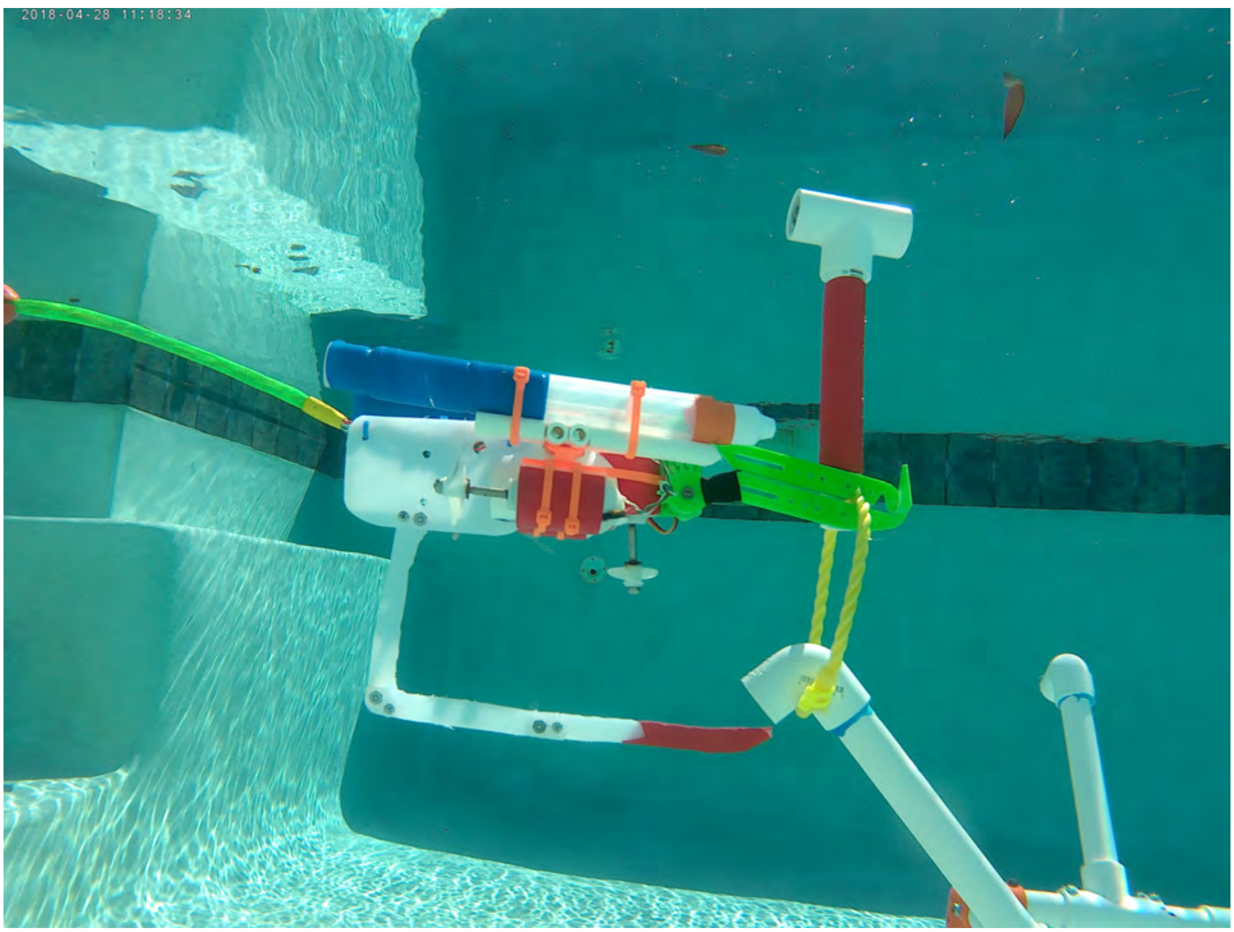
Our ROV has been successful for many reasons one being some of our new elements. Our design includes 3D printed attachments which allows for a more hydrodynamic design. Our ballasts can be adjusted to change our buoyancy from positive, negative, or neutral. With our adjustable buoyancy, we can easily maneuver through the challenge course and hoops course with the desired floatation in the front or back of our ROV. Our ROV also has a gripper that allows us to quickly grasp items that a hook could not. Our innovative design allowed for a faster, and more efficient ROV.

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

If we try our best, it will pay off! We spent 200 hours this year working on robotics. We faced many obstacles including losing team members, failed ROV experiments, and COVID. We gave it our best through all the challenges and were fortunate to learn a lot about engineering and teamwork. It has been a fun journey and we look forward to the experience competing in this year's SeaPerch Competition holds.

School or club name: Sandalwood High School
City, State: Jacksonville, Florida
Team name: Team Kraken
ROV name: Kraken 9

Seaperch 2022
Engineering Notebook



TEAM INFORMATION PAGE

ADVISOR NAME:	Mr. Christopher Shanklin
ADVISOR CONTACT:	scpkshanklin@gmail.com (224) 381-4310
TEAM NAME:	Kraken
TEAM PARTICIPANTS:	Kara, 9th Grade Paul, 12th Grade
SCHOOL:	Sandalwood High School
SCHOOL DISTRICT:	Duval County, Florida

TABLE OF CONTENTS

Engineering Design Process

November 7, 2018

ASK: Identify the need

IMAGINE: Brainstorm, Develop Possible Solutions.

PLAN: Make a prototype.

CREATE: Testing and Evaluating

IMPROVE: Modifying and Retesting

Team Goals

1. Obstacle Course < 35 sec. ☑
2. Challenge Course < 4 min. ☐
3. Win Regionals ☐ Internationals ☐
4. Have Fun !! ✓✓✓ (Had a Blast!)

Key

= Titles

= Design Terms

= Photo Labels

= Kraken Conclusion

Design Objectives

1. Decrease ROV's Size to increase thrust to mass ratio.
2. Decrease drag on the ROV to increase Speed.
3. add a tool to ROV Capable of Picking up items.
4. Increase Motor Performance.

Design Terms

November 14, 2018

Buoyancy: The ability to float, upward force exerted by a fluid on a body in it.

Trim: The way in which a ship floats on the water, in relation to it's force and aft line.

Stability: The ability of a ship to return to an upright position.

Hydrodynamics: Movements of liquids around bodies immersed in them.

Thrust: To push or drive quickly and forcefully.

Propulsion: The act of propelling using force or acting forces.

Velocity: Rate at which an object moves.

List: The angle of list is the degree to which a vessel leans or tilts to either port or starboard (often caused by uneven loading or flooding.)

Pitch: The forward movement of a boat propeller through one complete revolution measured in inches.

Design Terms

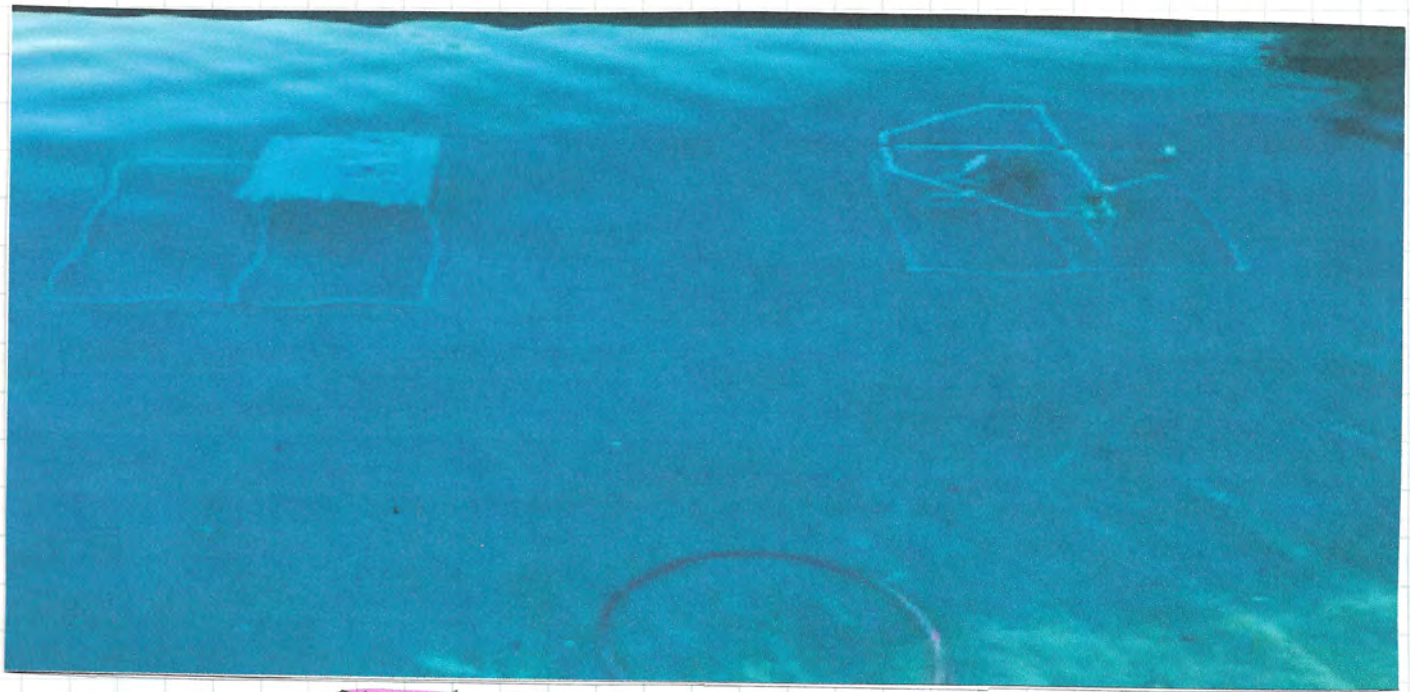
November 14, 2018

Ballast: The Sea water Carried by a Ship is Known as ballast water. Ballast water is carried by a Vessel in it's ballast tanks to ensure it's trim, Stability and Structural integrity.

Maneuverability: Performance ability of Ships related Ship Motion due to Steering.

Archimedes Principal: The upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces.

RPMs - Revolutions Per Minute.



Obstacle and Challenge Course

Tail of the Kraken

December 18, 2018

How can the ROV cable be lighter and more visible?

We could replace the original white cover with the light black sheathing.

Cable Photo

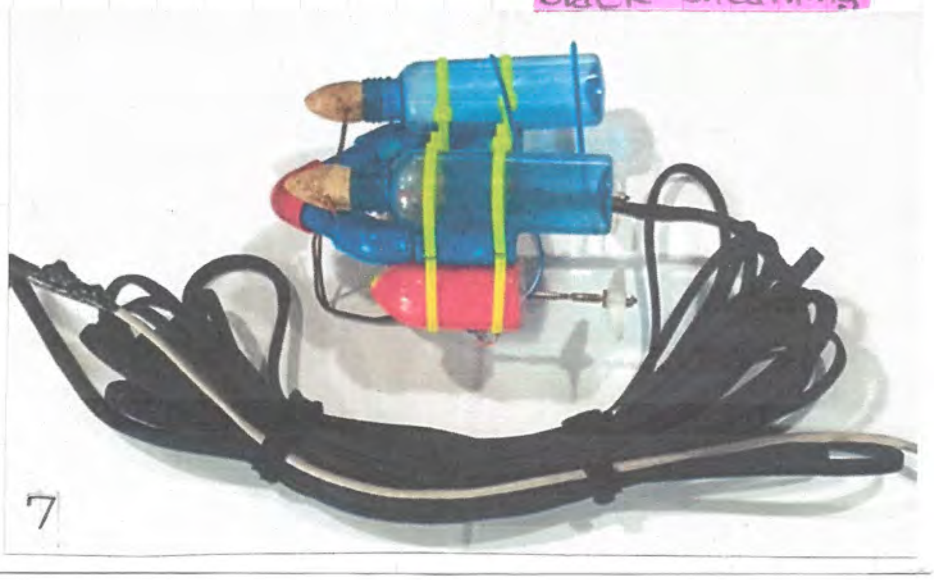
Black Sheathing   Seaperch Sheathing

We striped off the rubber and fed the wires through the Black Sheathing.

We observed that the black Shething was more manuverable and visible.

We can improve by using airtubing so our Sheathing is Buoyant and doesn't get in our way.

Kraken 4.0 with Black Sheathing



Kraken Conclusion

Based on the increased flexibility and visability we decided to go with the black expandable sheathing.

KraKen Power

December 21, 2018

How do we get more Power to the ROV?

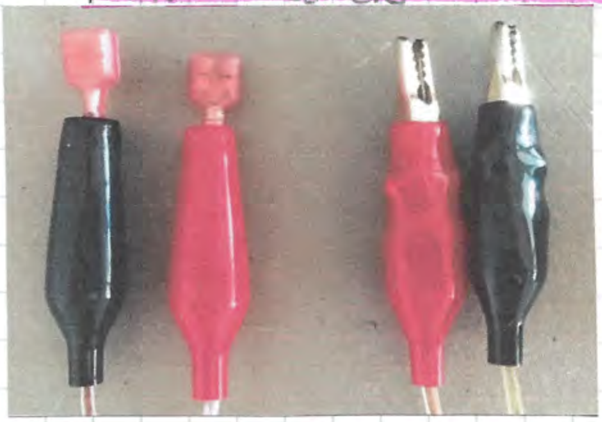
Will replacing the aligator clips with terminal leads produce more power to the motors?

Use a tachometer to test RPMs of a moter with clips and leads

Testing with clips and leads produced the same RPMs.

Will investigate more ways to get Power to the motors.

Photo of battery Connections



Terminal Leads Aligator Clips

RPM Testing

Kraken Conclusion

Although there was no difference in RPMs from the Aligator Clips and the terminal leads we decided to use the Aligator Clips because they stayed on better.

Digital Tachometer

KraKen Eye

January 15, 2019

Would a camera make it easier to pick up items in the Challenge Course?

We Should attach a camera to our hook that connects to a Screen for the driv[e] to look at.

Photo of wifi Endoscope

Photo taken by Endoscope

We are reaserching a non-wifi 50 foot cable.

We Purchased a camera from Amazon and tested it in and out of the water.

The endoscope camera's cabling was rigid and too short. Also, the video footage was low resolution and the video lagged.

KraKen Conclusion

We decided to not use the camera because it went over our budget.

Kraken fins

February 3, 2019

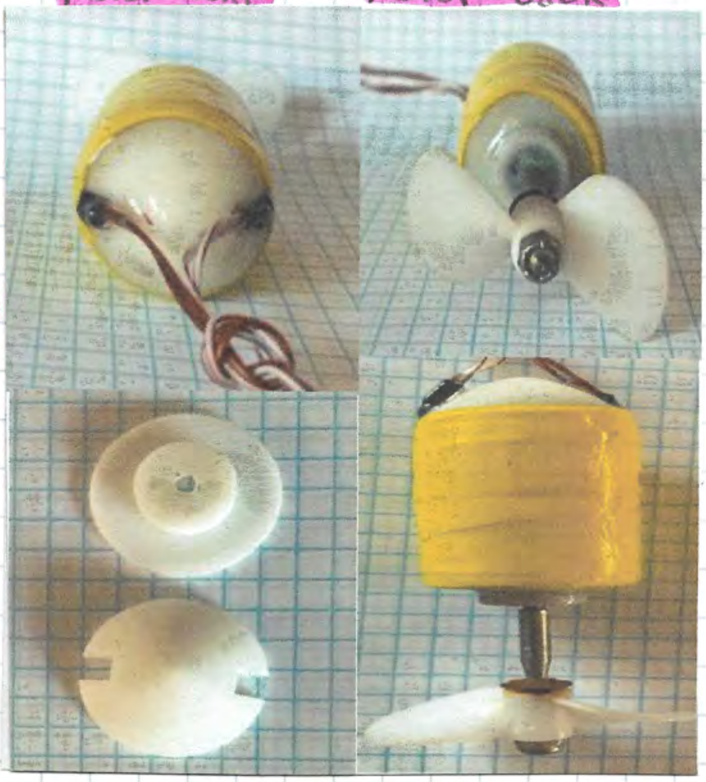
How do we improve Seaperch motors for more RPMs and less drag?

We should 3D print front and rear caps. We should use lubricated rope and marine grease to waterproof the shaft.

Photos of Motors

Motor Front

Motor Back



Motor caps

Completed Motors

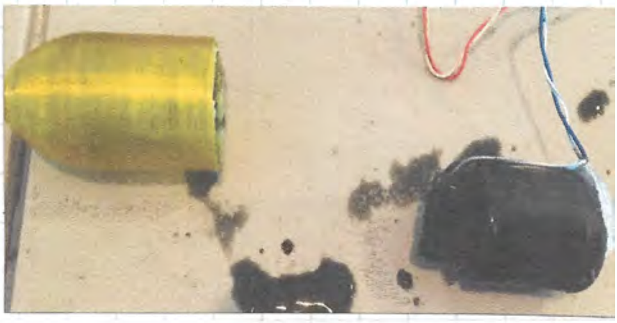
We printed caps and taped the motors. We used SLA resin and cured it with UV light to waterproof.

We will investagate ways to improve the motor caps hydrodynamics.

RPM testing before and after waterproofing

	Seaperch Before	Seaperch After	Kraken Before	Kraken Aft
Motor 1:	12,800	10,900	12,675	12,300
Motor 2:	12,550	11,900	12,780	12,220
Motor 3:	12,675	11,760	12,820	12,560

Photo of Original Motor caps



Kraken Conclusion

We decided to use the motor caps because they increased RPM Performance, were buoyant, and decreased drag.

18

Propeller Testing

March, 12, 2019

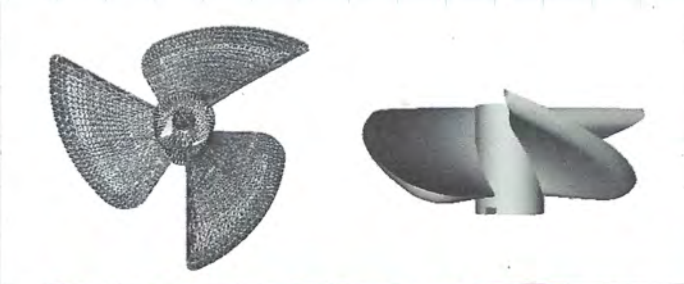
Would changing the number or size of the Propellers increase our Speed?

We Should add More blades to our Propellers and make them bigger.

We found Props of Various sizes and Shapes.

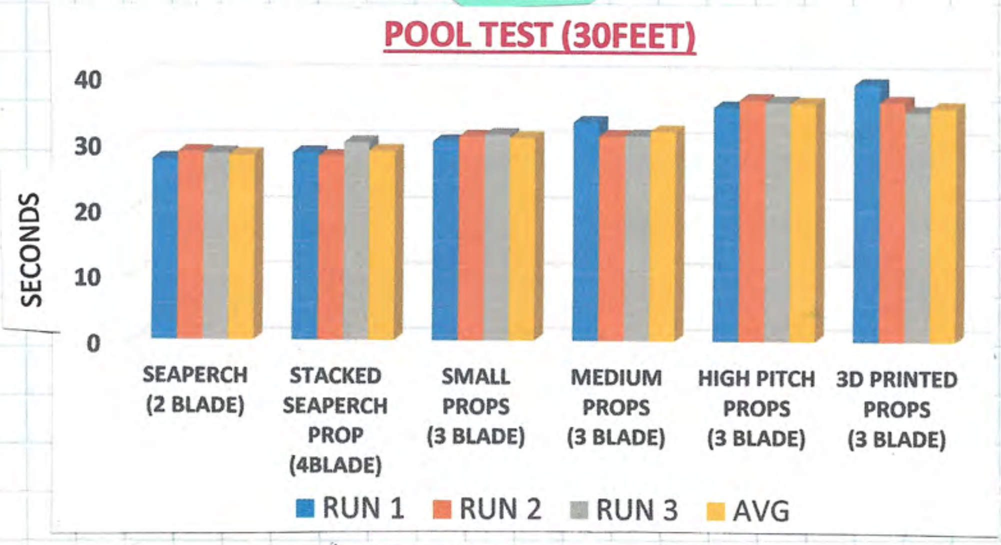
We Could try using Counter-rotating props with a Seaperch Shape.

Photo Of Tested Propellers



CAD - 3D Printed Propeller

Propeller test Results



Propeller Kraken Conclussion

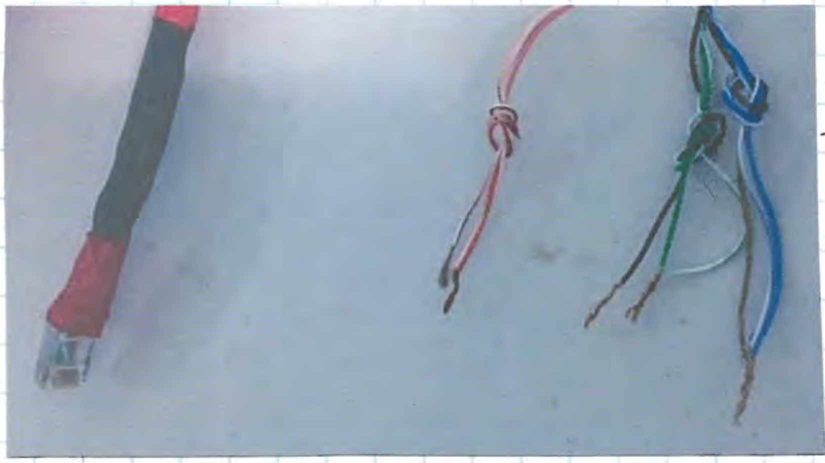
Seaperch props turned out to be the best So we'll continue to use them untill we find better props.

Kraken Current

April 24, 2019

How Can we Produce more RPMS from the motors with the limited 12 Volt battery?

We Could increas the Cable thickne to the motor termin to reduce resistan and increase Curre to the motor.



Picture Of Cable Doubling

We doubled up the Cat 5 Cable to all c the positive termanals and terminated the Cat 5 Cabl and RJ-45 Connector using a Spare Cable and heat sh

We used a tachometer to test RPMs of 3 new motors using identical battery voltage.

The reduced resistance improved RPMs, so we will investigate how to double up the negative terminal and fit it in the RJ-45 Connector.

Kraken Conclusion

Doubling up wires improves motor performance because it reduces resistance, increasing Current supplied to the motor (Ohms Law) That's why we used this improvement on our motors.

Wire resistance performance table.

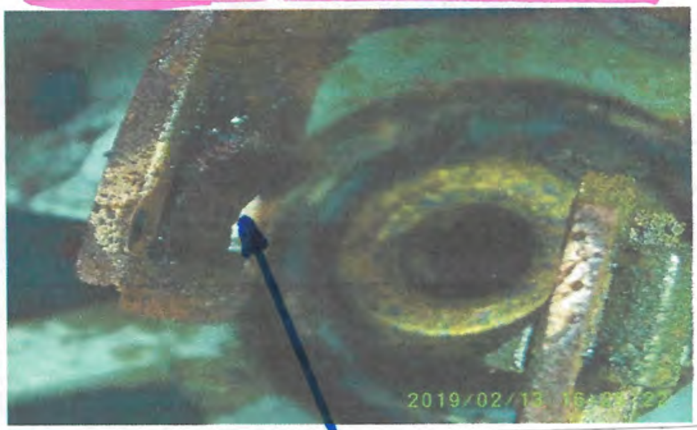
CABLE	WIRE RESISTANCE (Ohms)	VERTICAL MOTOR RPM	RIGHT MOTOR RPM	LEFT MOTOR RPM
SINGLE OLD CAT 5	4.4	11,100	11,220	11,180
SINGLE NEW CAT 5	3.5	11,610	11,670	11,650
DOUBLE NEW CAT 5	2.3	12,040	12,130	12.080

Motor Lessons

April 28, 2019

Picture Of New Motor Brushes

Picture Of Worn Motor Brushes



New Brush

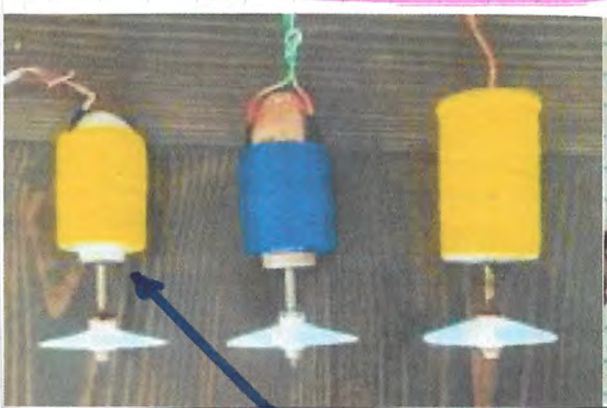
Worn Brush

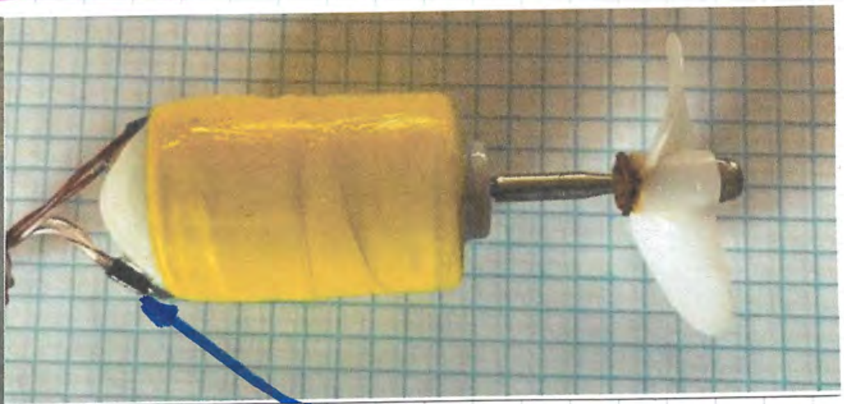
#1 ROV Failure: Motor Failure Cause: Worn motor Brushes

Description: As we practiced more we found motors fail at a high rate. When motor brushes wear down, like in the picture above RPMs decrease a lot.

Lesson Learned: Inspect the brushes or use new motors before Competitio

Pictures Of Sealed Motors





Shaft Motor Cap

Doubled Motor wire

#2 ROV Failure: Water in the motors Cause: Faulty motor Sealing

Description: As we pulled motors apart to figure out why they fail we noticed the motors failed when water leaked in through the shaft.

Lesson Learned: We used flat seal and marine grease under the 3D caps to reduce water intake through the shaft area.

Hydraulics

January 25, 2020

How can we create a gripper or claw to help pick up the sunken trash and the mines?

We should use syringes and air tubing to create a hydraulic system that we can attach a gripper/claw to.

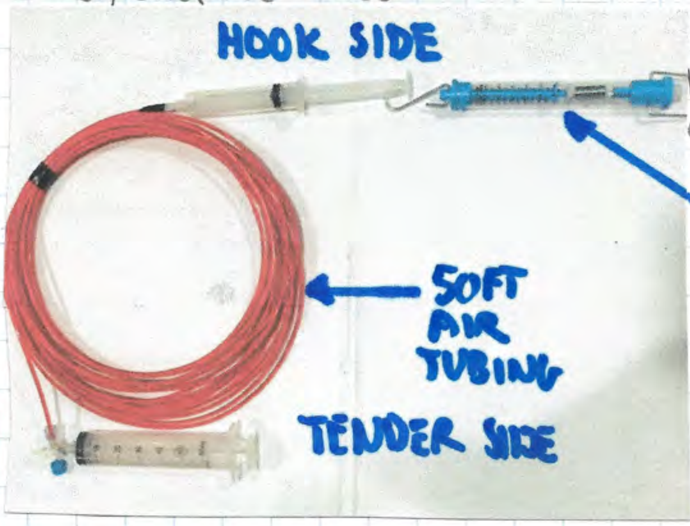


Photo of hydraulic testing

We took plastic syringes and air tubing along with water and created a hydraulic system to which we can add a gripper.

We tested the amount of time it took to extend/retract the plunger above and below the water.

Due to our failure with the hydraulics we are going to experiment with electric servos to create a stronger gripper.

Above water

Time to extend Plunger (seconds):
Trial 1: 1.65
Trial 2: 1.31
Trial 3: 1.25
Average: 1.40

Time to retract Plunger (seconds):
Trial 1: 3.39
Trial 2: 3.85
Trial 3: 3.66
Average: 3.63

Below water

Time to extend Plunger (seconds):
Trial 1: 1.51
Trial 2: 1.44
Trial 3: 1.63
Average: 1.52

Time to retract Plunger (seconds):
Trial 1: 4.05
Trial 2: 5.88
Trial 3: 4.00
Average: 4.64

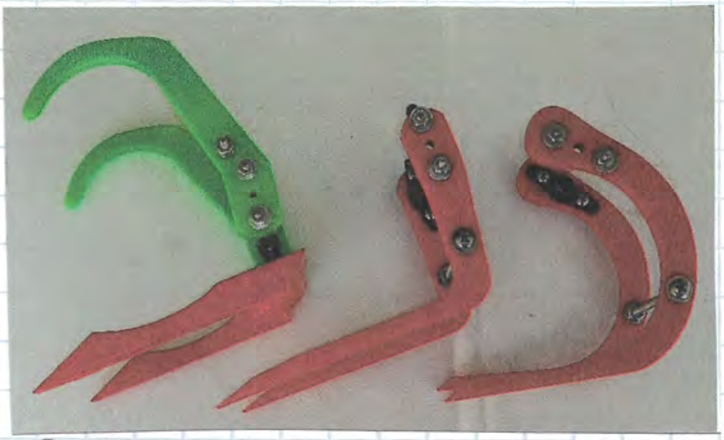
Pressure extending
12 Newtons
Pressure retracting
3 Newtons

Gripper

January 29, 2020

How can we pick up items from the top and bottom of the pool?

We could attach a servo motor in order to make a gripper.



Picture of Gripper progression

We designed a hook that could fit around the floating trash

We innovated our hook shape to better support laying our ROV on the bottom of the pool to pick up the sunken trash

Without Servo Motor	High Torque Servo Motor	High Speed Servo Motor
Items fall from the hook.	Closed onto the items and held them tight	Closed onto items faster; reduced jitter
	Had a jitter that often released items while driving the ROV	

Kraken Conclusion

We concluded that the two part gripper is necessary

Kraken Eye 2.0

January 22, 20

How do we increase Our Visability while underwater?

we could add a better quality camera to our Rov.

We used a Car backup Camera because it has a IP69k waterproof rating and is Small.

Because the Screen was Small and difficult to see, We are experimenting with a larger Screen.

Photo of the camera Screen

Since we used a Car backup Camera it was Much Smaller and lighter than our last Camera. On the Other hand, the Screen is Small and it is difficult to look between the Course and the Camera while driving.

Kraken Conclusion

This Camera was very efficient but Since we want to Compete in Stock Class during regionals we won't use it. However if we are selected to compete in internationals we plan to compete in open class and use it.

Camera and Servo Mount

Camera Base Station

Wireless Controller

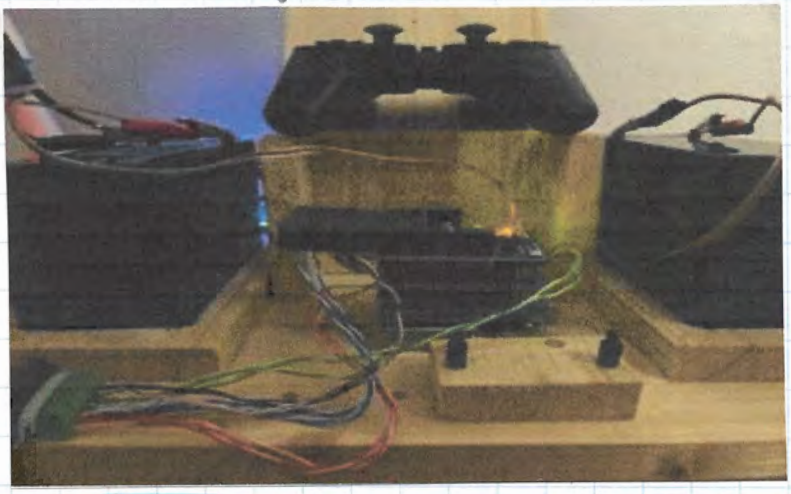
January 22, 20

How can we control our thrust to limit our speed while picking up items?

We could use a Joystick controller and program it so we can slowly speed up.

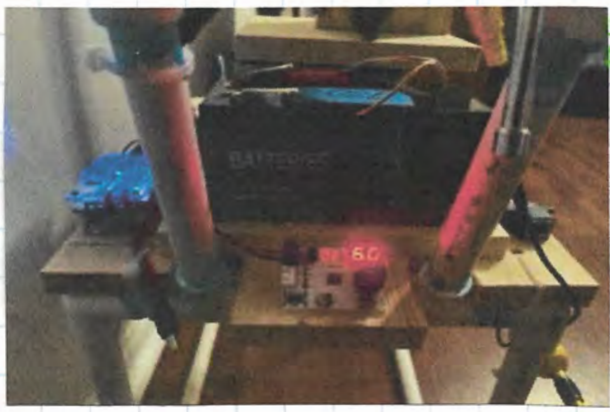
We ended up using a PS2 (Play Station 2) Controller to control ou[r] speed.

We are still experimenting with different controllers However, for now we plan to stick with the standard one.



Controller Base Station (Arduino)

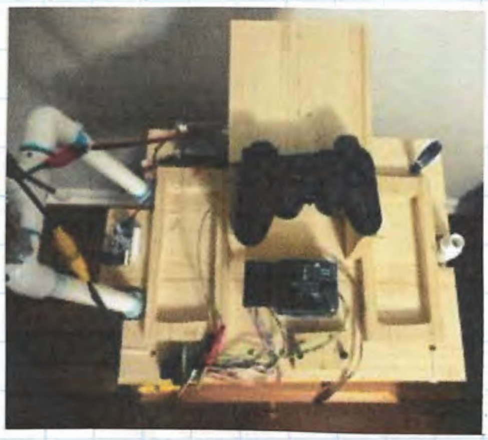
This controller worked perfectly, we were able to control our speed making it easier to line up with sunken trash and pick up items. However, our driver was more comfortable with the standard Seaperch controller.



Controller Base Station

Kraken Conclusion

Because we intend to compete in stock class for the regional competetion we are currently not using this controller, however if we make it to internationals we will switch to open class.



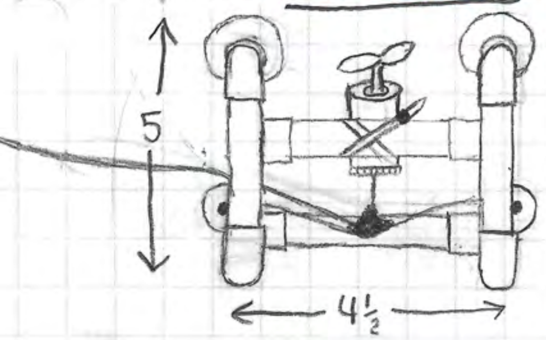
Arduino Base Station

Kraken 1.0

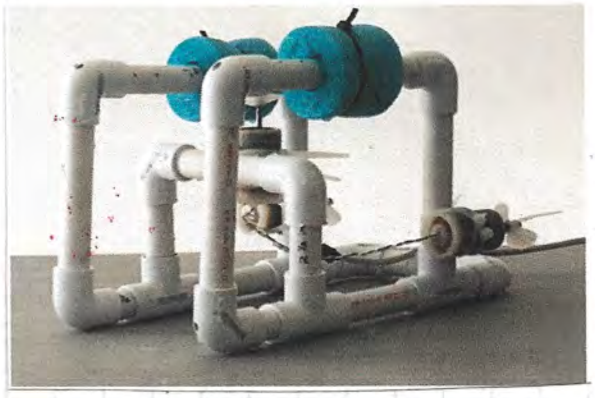
November 15, 2018

(Seaperch ROV design.

Front View

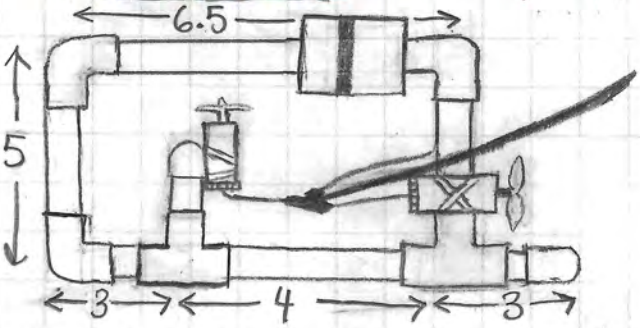


1 Block = 1 inch



Kraken 1.0 Photo

Side View



Problems with the ROV:

1. It's size would make it difficult to drive through the hoops course.
2. It does not have enough speed for Max. Points in the Challenge course.
3. Needs a way to pick up items.

Standard Pool test

Stability test

Trim - Neutral
List - Neutral
Buoyancy - positive
Weight - 704.4 grams

50 foot horizontal pool test

Trial 1 - 41.08 seconds
Trial 2 - 41.63 seconds
Trial 3 - 41.59 seconds
Average - 41.43 seconds

10 foot Vertical pool test

Trial 1 - 12.21 seconds
Trial 2 - 11.55 seconds
Trial 3 - 12.25 seconds
Average - 12.00 seconds

Kraken 2.0

November 17, 2018

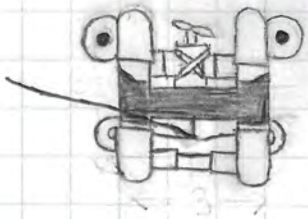
Would Minimizing the mass of the Standard Seaperch design increase our ROVS Speed?

We Should use thinn and Shorter pipe to increase our thrust t Mass Ratio.

We built a Smaller version of the Standard Seapearch RC
Length: 6in.
Width: 3½in.
height: 4in.

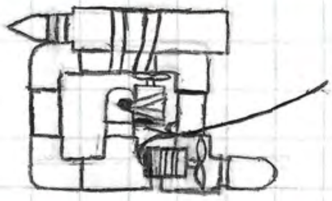
We modified the Standard Seaperch design by Replacing the foam with water bottles.

Front View



1 Block=1inch

Side View



Standard Pool test

Stability test

Trim-Neutral
List-Neutral
Buoyancy-Positive
Weight-231.6 grams

50 Foot Horizontal Pool test

Trial 1 - 39.63
Trial 2 - 35.49
Trial 3 - 36.15
Average - 37.09 seconds

10 foot Vertical Pool test

Trial 1 - 9.68
Trial 2 - 9.48
Trial 3 - 9.83
Average - 9.63 sec

Kraken Conclusion

Kraken 2.0 was stable but because of its Square Front we decided to Switch to a more hydrodynamic design.

Kraken 2.0 Photo

Kraken 3.0

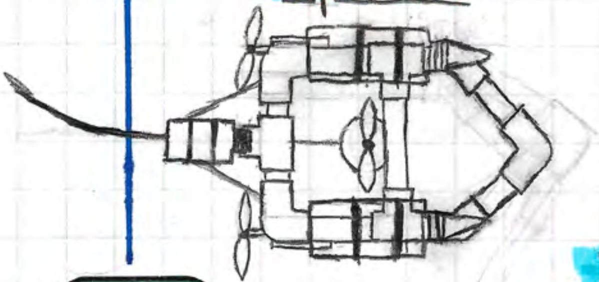
December 2, 2018

Would improving the hydrodynamics of our ROV make us faster?

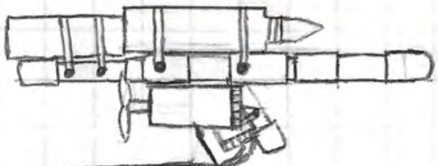
We Should improve our hydrodynamic by bringing our nose to a Point.

Scale: 1 Block = 1 inch

Top View



Side View



we built an ROV that is Shorter and wider with a Pointed nose.

we improved the hydrodynamics Of the last bot and the manuverablity.

Standard Pool Test

Stability test

Trim - Neutral
List - Neutral
Buoyancy - Positive
Weight - 159.9 grams

50ft. Horizontal Pool Test

Trial 1 - 30.19
Trial 2 - 30.33
Trial 3 - 29.7
Average: 30.07 seconds

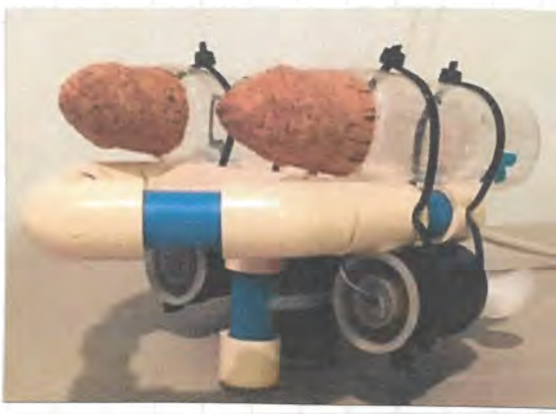
10ft Vertical Pool Test

Trial 1 - 9.89
Trial 2 - 10.01
Trial 3 - 9.93
Average: 9.94 seconds

Kraken Conclusion

Kraken 3.0 is our fastest ROV so far but it was super hard to control so we decided to switch to a more stable design.

Kraken 3.0 Photo



Kraken 4.0

December 9, 2018

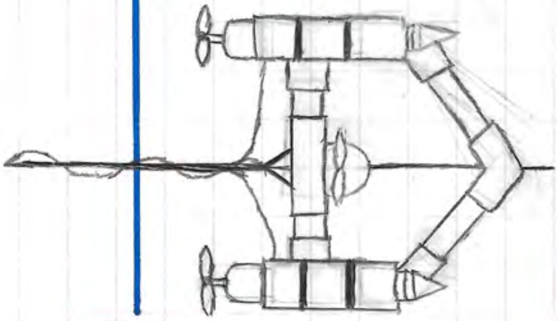
If we move the motor closer to the center of buoyancy will it improve the balance of the ROV?

We could increase the distance from bow to stern to place a motor closer to the Center Of Buoyancy

We built a Stingray shaped bot to prevent our ROV from flipping in the water.

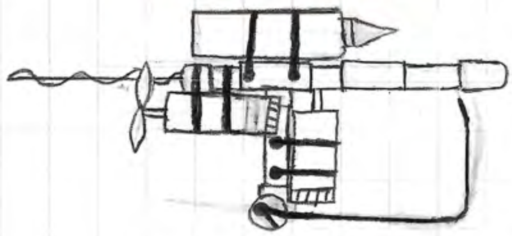
We increased the speed and vertical efficiency of our ROV.

Top View



Scale:
1 Block = 1 inch

Side View



Standard Pool Test

Stability test

Trim - Neutral
List - Neutral
Buoyancy - Positive
Weight - 127.5 grams

50ft. Horizontal Pool test

Trial 1 - 29.13
Trial 2 - 28.54
Trial 3 - 27.34
Average: 28.34 seconds

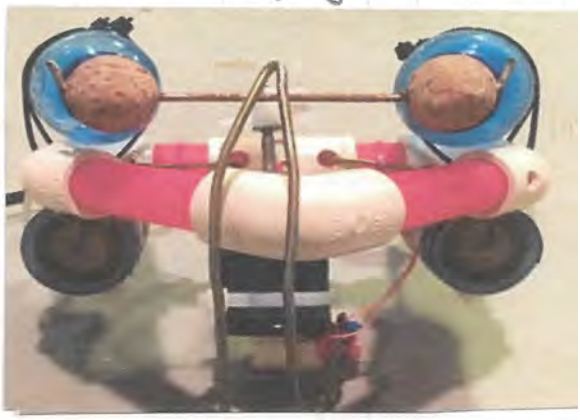
10ft. Vertical Pool test

Trial 1 - 8.64
Trial 2 - 8.37
Trial 3 - 8.42
Average: 8.47 seconds

Kraken Conclusion

Kraken 4.0 is our most hydrodynamic, stable, and easiest to control ROV. So we will continue to use Kraken 4.0 for competitions until we create a better ROV.

Kraken 4.0 Photo



Kraken 5.0

April 27, 2019

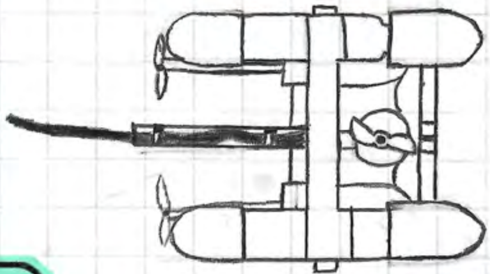
Winning regionals was great, but how do we make our ROV faster?

We could make our ROV lighter and smaller by 3D. Design and printing a frame

We designed a smaller frame in the fusio 360 Program. After that we Printed our frame. This reduced our ROV's overall size by approximately 50%

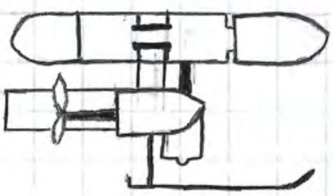
We will continue to improve our frame by adjusting motor placement for better control.

Top View



Scale:
1 Block = 1 inch

Side View



Standard Pool Test

Stability test

Trim - Neutral/adjustable
List - Neutral
Buoyancy - Positive/adjustable
Weight - 85.1 grams

50 ft. Horizontal pool test

Trial 1 - 27.87
Trial 2 - 27.28
Trial 3 - 26.81
Average - 27.33 seconds

10 ft. Vertical pool test

Trial 1 - 8.64
Trial 2 - 8.36
Trial 3 - 8.42
Average - 8.47 seconds

Kraken Conclusion

Kraken 5.0

We decided to change this design because, by 3D. Printing the entire frame we were able to increase our thrust to mass ratio and it was more manueverable.

Kraken 6.0

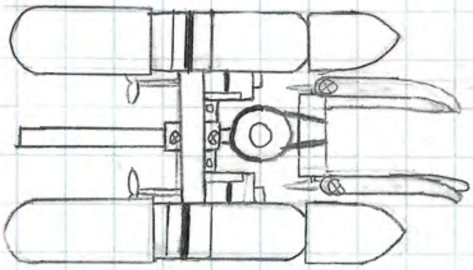
January 25, 202

How do we efficently pick items up from the bottom of the pool

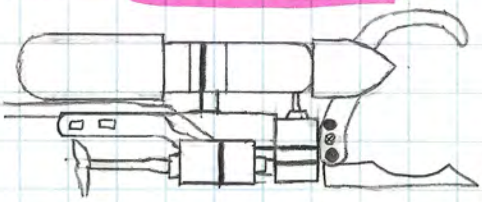
We Could make a more buoyant ROV that had an extra attachment allowing for a Servo.

We ajusted our bottle attachment and added ziptie holes to attach a Servo while still being hydrodynamic.

Top View



Side View



Kraken 6.0 worked great but would a single bottle design be faster and more manuverable?

Stability test	Standard Pool test: 30 ft Horizontal pool test	10 ft Vertical pool test
Trim - Neutral/adjustable	Trial 1 - 24.64	Trial 1 - 8.31
List - Neutral	Trial 2 - 23.99	Trial 2 - 8.37
Buoyancy - adjustable	Trial 3 - 24.63	Trial 3 - 8.41
weight - 48.2 grams	Average - 24.42 seconds	Average - 8.36 seconds

Kraken Conclusion

Kraken 6.0 worked great but it struggled with moving up/down while carrying items and was slower than we'd like.

Kraken 7.0

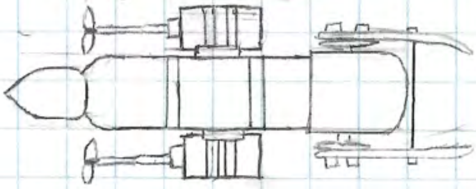
April 18, 2020

How do we increase the speed and manuverability of our ROV with a servo and gripper on it.

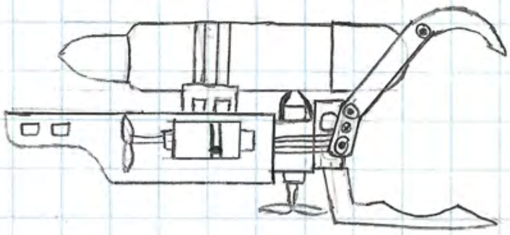
We could change to a one bottle design to make up for the additional drag added b the gripper.

Scale: 1 block = 1 inch

Top view



Side view



We modified our buoyancy attachment to a one botte design and flipped our vertical moto

We have made a lot of innovations to our ROV. We are now exprementing with a 4th motor for open class.

Stability test	Standard Pool Test 50ft. Horizontal Pool test	10ft. Vertical Pool test
Trim - Neutral/adjustable	Trial 1 - 22.97	Trial 1 - 9.15
List - Neutral	Trial 2 - 22.92	Trial 2 - 9.27
Buoyancy - Positive	Trial 3 - 22.21	Trial 3 - 9.31
weight - 38 grams	Average - 22.70 seconds	Average - 9.24 seconds

Kraken Conclusion

Although this design was faster, it was much harder to manuver and it would list towards port when driving on the surface. So until we came up with a better design we went back to practicing with Kraken 6.0.

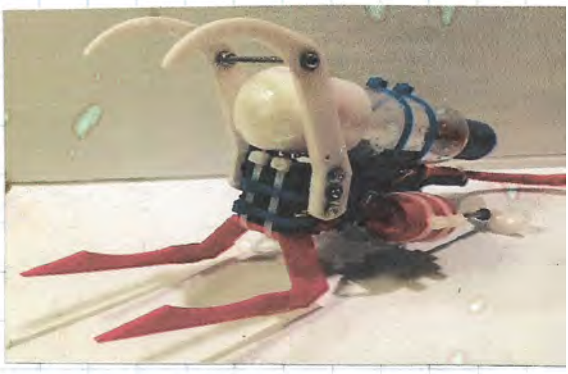


Photo of Kraken 7.0

Kraken 8.0

January 22, 2022

How do we increase our Stability and quickly remove floating trash from the ring?

Kraken 8.0 front view

Kraken 8.0 Side view

We could go back to a two bottle design which would drive straighter and incre manuverability.

We tried a new three bottle design and added a bulldoze attachment to assist with the floating tras

We ended up using this design for the 2021 international Competition. Now, with a New course we are experimenting with new designs.

Standard Pool Test

Stability Test

Trim - Neutral/adjustable
List - Neutral
Buoyancy - Positive
weight - 33.4 grams

50ft. Horizontal Pool Test

Trial 1 - 18.01
Trial 2 - 18.22
Trial 3 - 17.7
Average - 17.98 seconds

10ft. Vertical Pool Test

Trial 1 - 9.1
Trial 2 - 8.9
Trial 3 - 9.22
Average - 9.07 seconds

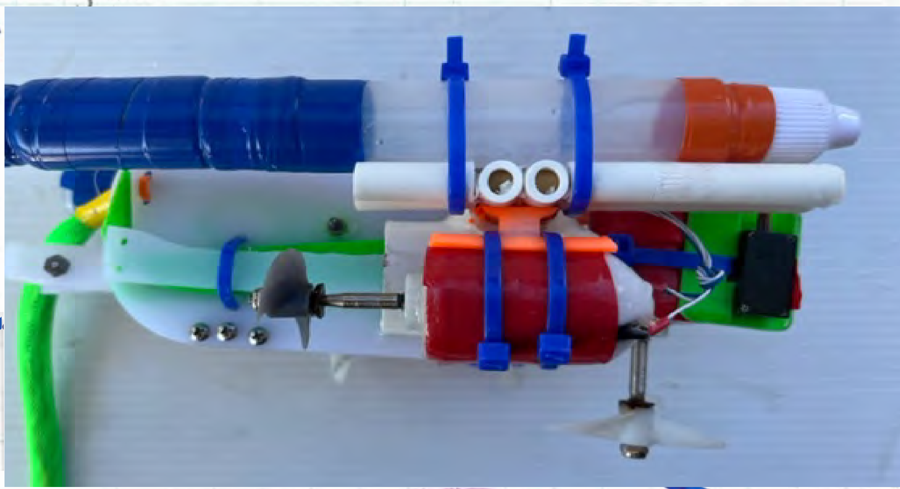
Kraken Conclusion

This design was very stable and allowed us to achieve the fastest time on the Challenge and Obstacle courses during the 2021 international Competition.

Kraken Final Design

January 22, 20

Cable bouys lightens Cable allowing ROV to drive Straignter.



Expandable Sheathing Increases Cable flexability.

Mini Servo, light and causes less drag.

Kraken 9.0 Compact Design

Retractable hook design, less drag for the Obstacle course.

Efficient PVC frame. It's hollow, allowing parts to be Stored in it for the Obstacle Course.

Gripper with forked hooks, Preven the tools from Slippi out.

Bright Colors helps us See our ROV. Different Colors helps us distinguish between the front and back of the ROV.

Kraken 9.0 Challenge Course Mode

Motor caps increas hydrodynamics.

BUDGET

Component	Vendor	How was component used?	Cost (in USD)
¼ Inch PEX Piping (1FT)	Home Depot	ROV Frame	$0.45
3/4 Inch PVC T Joint	Lowes	ROV Frame	$0.82
¼ Inch Wood Dowels 12 inch (1)	Amazon	ROV Frame	$0.17
3D Motor Caps (6-1 Gram each)	Self-designed/printed	Motor Waterproofing	$0.30
3D Gripper Fingers (2-5 Grams each)	Self-designed/printed	Gripper Fingers	$0.50
3D Horizontal Motor Holders (2-3 Grams each)	Self-designed/printed	Motor Holder	$0.30
3D Bottle Buoyancy (2-2 Grams each)	Self-designed/printed	Buoyancy	$0.20
3D Cable Buoyancy (4-4 Grams each)	Self-designed/printed	Buoyancy	$0.80
3D Servo Holder Part 1 (1-4 Grams)	Self-designed/printed	Servo Mount	$0.20
3D Servo Holder Part 2 (1-2 Grams)	Self-designed/printed	Servo Mount	$0.10
3D Button Holder (1-1 Gram)	Self-designed/printed	Button Mount Controller	$0.05
3D Printed SeaPerch propellor (CW) (1-1 Gram)	Self-designed/printed	Counter Rotating Propellor	$0.05
Servo (MG90S) (1)	Ebay	Gripper Actuator	$1.89
Servo Controller (1)	Aliexpress	Servo Operation	$3.28
4 Pack Battery Holder (1)	Amazon	Servo Power	$2.96
1.5V Batteries (4)	Amazon	Servo Power	$0.84
SPDT Button	Amazon	Servo Operation	$1.10
Servo Wiring (CAT 5 – 40 Feet)	Amazon	Servo Power	$2.40
Gripper Fishing Line	Amazon	Prevent Course Tangle	$0.10
30ml Plastic Bottles (2)	Amazon	ROV Buoyancy	$0.72
15ml Plastic Bottles with Cap (2)	Amazon	ROV Buoyancy	$1.16
Cable Sheathing (35 Feet)	Amazon	Cable Collection	$3.15
Heat shrink (9 pcs)	Amazon	Wire Waterproofing	$0.17
Lube Compress Packing Seal	Amazon	Motor Waterproofing	$0.30
SLA Resin	Amazon	Motor Waterproofing	$0.30
Marine Grease	Amazon	Motor Waterproofing	$0.09
4-40 Screws/Nuts (6 Screws, 6 Nuts)	Amazon	Hook Hardware	$0.60
Plastic Cutting Board (<50% used)	Dollar Store	Hook	$0.63
TOTAL COST OF SEAPERCH COMPONENTS			$23.63

REFERENCES

1) Webster's II New Riverside Dictionary (office edition), Houghton Mifflin company 1996 Berkley Street, Boston
2) Wing, Charlie. how boat things work an illustrated guide, 2004-2007
3) I.C.B. Dear. Kemp, Peter. The Oxford Companion to Ships and the Sea., Oxford University Press Inc. 2005
4) https://www.seaperch.org/build (Seaperch Construction Manual – 2016-01 (PDF 3.0 MB)
5) http://www.seaviewsystems.com/questions/what-is-an-rov/ , Seaview Systems Inc 1998, Dexter, MI, 7275 Joy Road
6) Www.oceaneering.com. (n.d.). Remotely Operated Vehicles (ROVs). Retrieved January 29, 2019, from https://www.oceaneering.com/rov-services/
7) What Are Underwater ROVs & What Are They Used For? (2018, June 18). Retrieved from https://www.deeptrekker.com/underwater-rovs/?locale=en.
8) Farndon, J. (2003). *Buoyancy*. Tarrytown, NY: Benchmark Books.

TEAMWORK MAKES THE DREAM WORK