TECHNICAL DESIGN REPORT: BLEJAB ROV

1. ABSTRACT

This Technical Design Report outlines the Engineering Design Process (EDP) employed by Team BLEJAB to create the BLEJAB Remotely Operated Vehicle (ROV) and highlights its successful design features. The report examines the challenge course, obstacle course, and new mini course tasks and how they influenced the team's engineering design approach. Furthermore, the report presents an analysis of experimental results, demonstrating how thorough testing informed the final design. The report also includes the team's reflections on the SeaPerch journey up to this point, as well as future plans for both the BLEJAB ROV design and team members. The BLEJAB ROV boasts several unique design features, setting it apart in the SeaPerch community:

- **Pinpoint Buoyancy Design**: The pool noodles provided additional buoyancy to the ROV, which allowed it to float more easily in the water. Additionally, the pool noodles helped to evenly distribute weight throughout the ROV, which improved its balance and stability in the water.
- **Streamlined Design**: The frame is hollow to provide maximum thrust to mass ratio (Wing, Charlie, 2004, 2007) for peak ROV speed.
- **Innovative Parts**: The ROV front-mount hook is made from two coat hangers and is used for grabbing and transporting the sea creatures and the water sample.
- **3D Printed Water Deflector**: These deflectors (holding the motors in place), both keep the ROV streamlined while enhancing the motor's capabilities.

2. TASK OVERVIEW

The pool mission consists of four tasks divided into two sections, the Obstacle Course and the Mission Course. By following the EDP, Team BLEJAB should be able to successfully navigate the challenges in the time limits required to achieve as many points as possible on all tasks:

- *Mapping the Seafloor* - To map the seafloor, the ROV will simulate the grid pattern used by researchers by moving grid line indicators (floats attached with ropes) along grid lines (pipes) in a lawn-mowing pattern. To improve seafloor mapping performance, the BLEJAB ROV was equipped with a "divot" in the front so as to be able to move the grid line indicators more effectively.
- *Marine Life Interaction* - The ROV will carefully remove and relocate marine life that has settled on target areas, ocean bottom laboratory structures, or other equipment to avoid impeding operations or causing harm to the marine life. The BLEJAB ROV was modified with a specialized hook tool to enable more efficient removal and relocation of marine life during interactions.
- *Water Sample Collection* - The ROV will be tasked with collecting water samples from the regions below the Autonomous Surface Vehicle (ASV) and transporting them back to the sample collection area. To do so, the ROV must activate a target flag before retrieving a water sample and transporting it to a drop-off hook located at the front of the mapping grid. The BLEJAB ROV was customized to include a specialized water collection hook, designed to be able to quickly unhook and rehook the water samples, to improve the efficiency and accuracy of water sample collection.
- *Obstacle Course* - Requires diving, surfacing, and traveling through five vertical and horizontal hoops in the least time possible. Team BLEJAB's enhanced hydrodynamics (Lucas J., 2014), motor improvements, and streamlined frame should result in a quick completion of the obstacle course.

3. DESIGN APPROACH

Team BLEJAB employs detailed techniques to innovate throughout the Engineering Design Process (EDP).

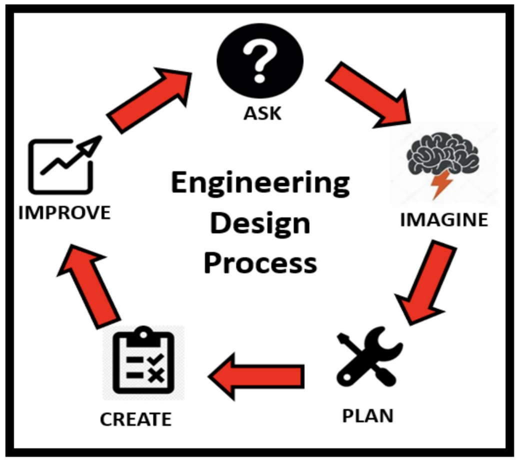


Fig. 1 - EDP Diagram

ASK: The first step is to survey the tasks and identify necessary improvements for efficient course completion. Team BLEJAB focuses on the following questions: How can the ROV's speed be optimized? How can buoyancy (OpenStax College, 2013) be adjusted for different scenarios? How can items be lifted and transported?

IMAGINE: The team brainstorm ways to solve these questions with priorities to improve attachments for the mission course, reduce frame size and drag, and increase motor RPMs.

PLAN: Each design feature is planned with detailed drawings, materials, building techniques, and testing methods.

CREATE: After planning, Team BLEJAB moves on to the building/testing phase for each iteration, testing each improvement to make informed design decisions.

IMPROVE: Test results are analyzed to make final decisions, taking design tradeoffs into consideration.

DESIGN ITERATIONS

	Overall Weight	Speed (Forward, Backward, Up, Down) in Seconds	Pros	Cons
BLEJAB 1.0	38.6 oz.	F - 2.75 / B - 5.23 U - 4.84 / D - 4.36	Stable	Slow, Sluggish Maneuverability (Moore S.W., 2010)
Description: Team BLEJAB chose to use the stable standard SeaPerch frame as a baseline for their next design, but opted to make it smaller.				
BLEJAB 2.0	38.6 oz.	F - 2.52 / B - 5.08 U - 6.06 / D - 3.14	Stable, slightly faster	Clunky, inconsistent piloting, bad hook
Description: The team confirmed that reducing size and weight of the design resulted in increased speed. Although the design was stable and maneuverable (Wing, Charlie, 2004, 2007), they opted to redesign it to explore how enhancing hydrodynamics impacts the ROV's performance.				
BLEJAB 3.0	34.4 oz.	F - 2.45 / B - 4.95 U - 5.84 / D - 2.99	Stable, adequate buoyancy	Slow, hook did not balance well
Description: By incorporating a pointed front, this iteration of the design confirmed that enhanced hydrodynamics (Lucas J., 2014) leads to greater speed. However, the ROV proved				

challenging to maneuver during diving and surfacing. The team hypothesized that this issue stemmed from the hook placement and center of buoyancy, prompting them to modify these factors in a subsequent redesign.				
BLEJAB 3.5	28.2 oz.	F - 2.25 / B - 4.80 U - 5.80 / D - 2.88	Lightweight, faster, stable	Insufficient hook
Description: Slightly shortened the ROV frame and effectively removed the hook. This design justified that reducing size and drag increases speed and hook location dramatically affects ROV control. The team also made modifications to the 3D printed deflector to improve motor capabilities.				
BLEJAB 4.0	29.1 oz.	F - 2.36 / B - 2.80 U - 5.75 / D - 2.95	Lightweight, stable, sufficient hook	Some buoyancy and balance issues.
Description: Team BLEJAB had to account for the hook for the Mission Course. The new hook did not greatly impact the design, but the robot still struggled to keep hooked items. This new design was not as balanced as the previous one, a trade off we had to make for the hook.				

Fig. 2 - BLEJAB 2.0

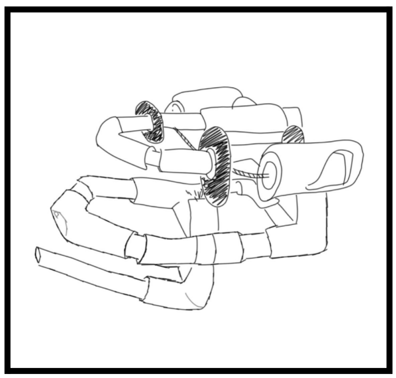


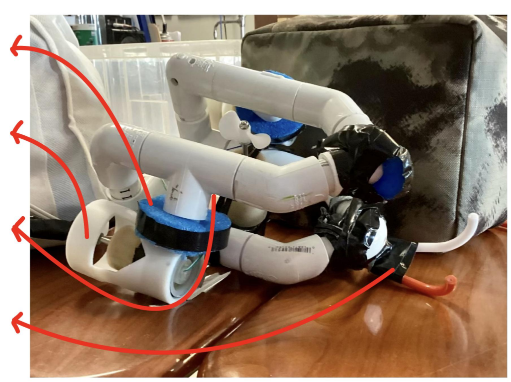
Fig. 3 - BLEJAB 3.0

Fig. 4 - BLEJAB 4.0

FINAL DESIGN DISCUSSION/FEATURES -

Team BLEJAB's latest frame incorporates a smaller front hook, affixed to the ROV's lower bar. Although adding the hook presented significant challenges and added weight (0.90 oz), the enhanced functionality it provides makes it a necessary addition. In combination with other improvements, this design represents the team's most innovative ROV to date. Additional distinctive features include:

Buoyancy Regulator: Pool noodle used for balance and buoyancy control.
Water Deflector: Redirects water for better propulsion efficiency.
Wire Containment: Prevents entanglement of ROV's wires and cables.
Front Hook: Used to grab and manipulate objects in the water.



4. EXPERIMENTAL RESULTS

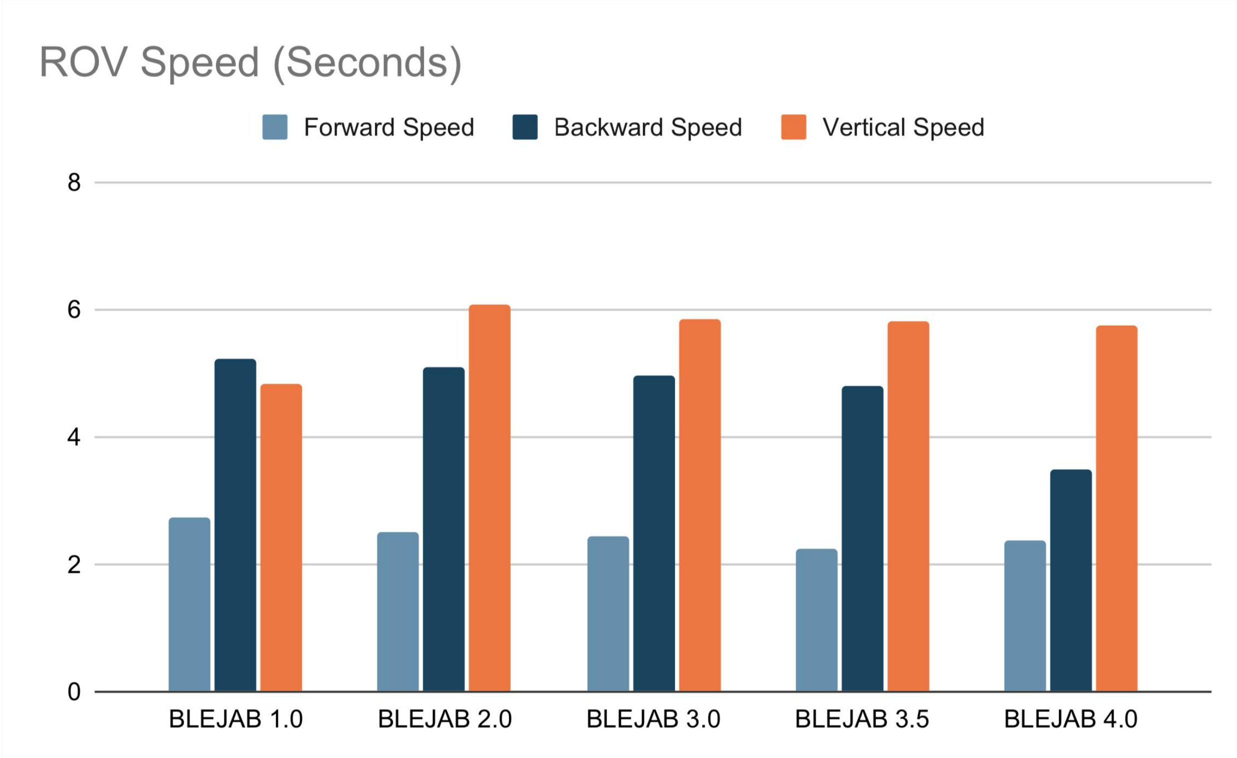


Fig. 5 - Speed Column Chart

Speed Test: For Team BLEJAB, the most important ROV design factor is speed. The team conducts in-water testing of each ROV, roughly 6 feet in our outdoor tank for each ROV design.. 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 BLEJAB ROV final design.

Prop Test: A 5-second speed test of propellers is conducted prior to any speed test to analyze performance of propellers. Testing visually indicated any propeller obstructions and was crucial to any further testing. Testing evaluation demonstrates the SeaPerch propeller was unobstructed and was very effective.

Lifting Test: Later designs featuring hooks were evaluated using a sample sea creature from the mission course. Testing involved dropping the sea creature into the tank and testing the robot's underwater lifting capabilities. Other observations included ROV balance/security while holding the sea creature, ROV speed while holding the sea creature, and the ROV's ability to drop the sea creature.

Hook Durability Test: To assess the durability of the hooks used on the ROV, a rigorous testing process was conducted. Each hook was subjected to repeated stress tests, simulating the strains and forces they may experience during underwater operations. This included testing their ability to bear weight, resist bending or warping, and maintain their integrity when exposed to various types of water conditions. The hooks were also evaluated for their resistance to wear over time. The results of these tests informed the team's decision on which hook to use in the final design, ensuring maximum durability and reliability of the ROV in mission scenarios.

5. REFLECTION AND NEXT STEPS

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

- **Ask**: The team built and tested the course to identify imperfections and raised questions about improving ROV speed, increasing motor performance, and navigating challenges.
- **Imagine**: Coaches challenged the team to use different materials and ideas, leading to innovations in 3D design and motor improvements.
- **Plan**: The team researched and planned for materials, timelines, and new innovations to be more prepared.
- **Create**: Building and constructing each ROV and its parts was time-consuming, but led to the creation of the MFV which decreases manufacturing, repair, and redesign time.
- **Improve**: The team constructed nine different ROV design iterations and assessed their performance, leading to improvements.

Overall, the EDP helped Team BLEJAB achieve success and continues to guide them towards their goals.

Team's Future Plans:

Team BLEJAB's freshman members have a bright future ahead of them as they continue to hone their skills in engineering and robotics. In the coming months, the team plans to provide these members with opportunities to learn new techniques and apply their knowledge to real-world challenges. With these plans in place, the freshman members of Team BLEJAB are well positioned to contribute to the team's continued success in the years to come.

BLEJAB ROV Future Plans: *(Potential Real-World Application)*

The BLEJAB ROV has already undergone several iterations and improvements, but there is still potential for future plans to further enhance its capabilities. One potential area of focus could be on increasing the ROV's maneuverability, either through the addition of new thrusters or through modifications to the existing propulsion system. Additionally, the team could explore ways to improve the ROV's imaging and data collection capabilities, such as incorporating new sensors or cameras. Furthermore, the team could also explore new applications for the ROV, such as environmental monitoring or search and rescue missions. This would require modifications to the ROV's design and functionality, but would expand its potential impact and usefulness.

Lessons Learned:

The Seaperch Project has provided many valuable lessons and insights for the individuals and teams involved. Some of the key lessons learned from this project include:

Importance of teamwork: The Seaperch Project involves collaboration and teamwork at every stage, from the design and construction of the ROV to its deployment and operation. Team members learn to work together effectively, communicate clearly, and leverage each other's strengths to achieve their goals.

Hands-on learning: The Seaperch Project provides a unique opportunity for hands-on learning in science, technology, engineering, and math (STEM) fields. Participants are able to apply their classroom knowledge to a real-world challenge, gaining valuable practical skills and experience.

Problem-solving skills: The Seaperch Project requires participants to think creatively and develop innovative solutions to design and operational challenges. This cultivates problem-solving skills that can be applied to a variety of contexts and situations.

Persistence and resilience: The Seaperch Project can be challenging and requires perseverance and resilience. Participants learn to persist in the face of setbacks and obstacles, and to adapt their approach as needed to overcome challenges.

6. ACKNOWLEDGEMENTS

We would like to take a moment to acknowledge and express our deep appreciation for the support and guidance we have received throughout our participation in the Engineering Design Process for the Seaperch Project.

First and foremost, we would like to thank the parents of our team members for their unwavering support throughout this project. Your encouragement, enthusiasm, and dedication have been invaluable, and we could not have succeeded without your tireless efforts. Your willingness to provide transportation, assistance with fundraising, and other forms of support made this project possible, and we are deeply grateful for everything you have done for us.

We would also like to thank our school for providing us with the opportunity to participate in this project. Your commitment to STEM education and your support of our team has been instrumental in our success, and we are proud to represent our school in this endeavor.

Finally, we would like to express our gratitude to our teachers, Mr. Geppert and Mr. Wood, for their exceptional instruction and mentorship throughout the Engineering Design Process. Your expertise, dedication, and patience were essential to our success, and we are fortunate to have had such inspiring and knowledgeable instructors guiding us through this process. Your guidance and support have not only helped us succeed in this project but have also given us valuable skills and experiences that we will carry with us throughout our lives.

In conclusion, we are deeply grateful for the support and guidance we have received throughout our participation in the Seaperch Project, and we will always remember the contributions of our parents, school, and teachers with the utmost appreciation and respect. Thank you for helping us achieve our goals and for inspiring us to pursue excellence in all that we do.

7. REFERENCES

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Appendix A - BUDGET

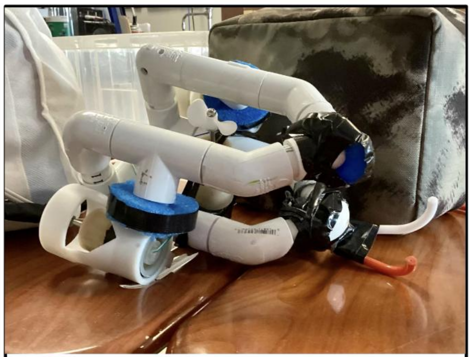
Component	Vendor	How Was Component Used?	Total Cost of Item
45* PVC Elbow	Home Depot	ROV Frame	$1.00
Duct Tape	Home Depot	Securing Pool Noodle	$0.60

Spray Foam	Lowes	Buoyancy	$0.05
Total Overall Cost:			**$1.65**

Appendix B - Fact Sheet

Team BLEJAB

Cape Henlopen High School - Lewes, Delaware



HS-Stock

Years participating in SeaPerch 1

Times at the International SeaPerch Challenge NA

Our SeaPerch is unique because: (100 words MAX)

The BLEJAB ROV boasts several unique design features:

- **Pinpoint Buoyancy Design**: The pool noodles provided additional buoyancy to the ROV, which allowed it to float more easily in the water.
- **Streamlined Design**: The frame is hollow to provide maximum thrust to mass ratio for peak ROV speed.
- **Innovative Parts**: The ROV front-mount hook is made from two coat hangers and is used for grabbing and transporting the sea creatures and the water sample.
- **3D Printed Water Deflector**: These deflectors (holding the motors in place), both keep the ROV streamlined while enhancing the motor's capabilities.

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. Team BLEJAB's latest frame incorporates a smaller front hook, affixed to the ROV's lower bar. Although adding the hook presented significant challenges and added weight (0.90 oz), the enhanced functionality it provides makes it a necessary addition. In combination with other improvements, this design represents the team's most innovative ROV to date.

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

- Importance of teamwork: The Seaperch Project involves collaboration and teamwork at every stage, from the design and construction of the ROV to its deployment and operation. Team members learn to work together effectively, communicate clearly, and leverage each other's strengths to achieve their goals.
- Problem-solving skills: The Seaperch Project requires participants to think creatively and develop innovative solutions to design and operational challenges. This cultivates problem-solving skills that can be applied to a variety of contexts and situations.