## 1) ABSTRACT

This technical design report outlines the team's Engineering Design Process (EDP) employed by the team, Steven's Wonder6, to design and construct the SW6 Remotely Operated Vehicle (ROV). Moreover, this report describes the challenge course, obstacle course, and all of their components. The report also includes reflections on the next steps of members after undertaking the team's first international challenge. Through this report, we detail the endeavors and challenges that our team has faced to manufacture a high-performing ROV, boasting unique features such as:

- **Custom Motor Mounts**: These mounts reinforce and stabilize the ROV's motors, while their lightweight 3D-printing material allows the ROV to still accelerate without excess weight.
- **Stabilizing bar at the front of the ROV**: The bar allows stability when influencing game assets, inspired by carrier helicopters.
- **Custom Hook Joints**: These joints allow the front hooks to be attached to the ROV and complete objectives in the mission course.


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## 2) TASK OVERVIEW

**The Obstacle Course:**

The obstacle course contains five 18" diameter hoops set up at different angles. The ROV must start the run surfaced within the outline. Once the run starts, the ROV must pass through each of the 5 hoops, from closest to farthest. Then, the ROV must resurface, resubmerge, and pass through the obstacle course in reverse order. The run is completed when the ROV resurfaces within the starting outline.

**The Mission Course:**

The mission course must be completed within 8 minutes. Begin by submerging and removing the octopus from the hatch, and relocating it to the platform. Then, open the hatch to move new species into the biobuckets underneath. Close and relatch the hatch, followed by relocating the coral samples found in the biobuckets to the coral tree. Next, relocate the sea sponge and deep-sea coral to the biobuckets. Place the blue sensor next to the coral tree and the red sensor on the deep dive platform, and end the run by resurfacing within the outline of the surface vehicle.

**Design Approach Justification:**

As we went through the mission course, we realized that many tasks required precise object displacement. With this in mind, we aimed to make our ROV focus on stability and strength over speed. We believe that an overly quick ROV would be difficult to control and impede our ability to carefully influence the mission course pieces. To achieve this, we made a rectangular base design with a large frontal surface area. This would make the final ROV slower than most, but balanced and easy to handle. Additionally, we omitted using the zip ties that came with the design kit and designed custom 3D-printed motor mounts for all 3 motors to increase the stability of our ROV's propulsion system.

## 3) DESIGN APPROACH

Steven's Wonder6 employs strategic planning to drive innovation through a five-stage Engineering Design Process (EDP):

1. ASK: What are the shortcomings of our current ROV iteration?
2. IMAGINE: What can we do to address these shortcomings whilst maintaining our design philosophy of good handling and a stable frame?
3. PLAN: Who is best at what? How can we assign each member tasks to maximize efficiency?
4. CREATE: In this stage, we assemble all of our resources and ideas to create a high-functioning ROV for the challenge.
5. IMPROVE: By subjecting the ROV to extraneous amounts of heavy testing, our team can point out flaws of the ROV, recognizing areas that need improvement.

**Design Iterations**

**SW6 (Beta)** ***Pros*****:** Easy to construct and begin practice with, light

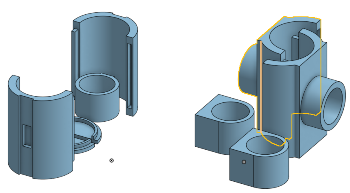
***Cons*****:** Unbalanced.

**Desc:** This was our team's first attempt at constructing an ROV and many of our member's first time learning to use the tools and materials. Upon completion, we immediately noticed that the design we used was unbalanced, especially toward the back end of the ROV, which made it difficult to maneuver.

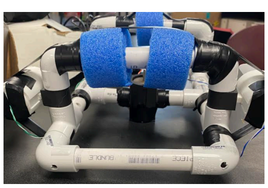
**SW6 Iteration I** ***Pros*****:** Strong and stable, swift rotation.

***Cons*****:** Too buoyant, unable to sink.

**Desc:** Building the beta revealed the need for a sturdy frame, achieved by lengthening the base, making the frame shorter, and adding 3D-printed motor mounts. Testing this iteration exposed excessive buoyancy, which prevented submersion, and an imbalance due to measurement errors



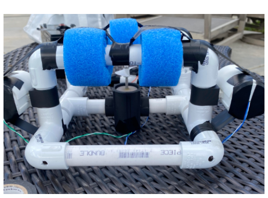
(Models of Horizontal and Vertical Motor Mounts)



**SW6 Iteration II** ***Pros*****:** Agile

***Cons*****:** Unbalanced ascension

**Desc:** To address buoyancy, we reduced front buoyancy by 33% and rear by 66%, compensating for front heaviness from the motors. This enabled submersion and reduced frontal drag for speed but caused veering during ascent.



**SW6 Iteration III** ***Pros*****:** Faster, smaller.

***Cons*****:** Unbalanced ascension, poor rotation.

**Desc:** Further shortening the ROV by 3 inches in this iteration improved hoop clearance and acceleration, while an imbalance from measurement errors remained.

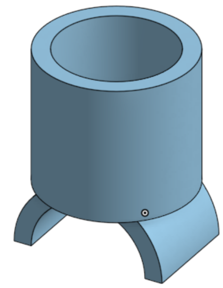
**SW6 Iteration IV** ***Pros*****:** Faster and stronger.

***Cons*****:** Handling was not optimal.

**Desc:** In our fourth iteration, we continued to reduce the mass of the ROV by making its width shorter by 1 inch. This also increased acceleration and allowed for more clearance when moving through hoops.

**SW6 Iteration V (Final)** ***Pros*****:** Balanced, Agile horizontal.
***Cons*****:** Slow descent, difficulty moving objects.
In our final iteration, we added the hooks to influence the mission course assets. This also had the effect of fully balancing the ROV. That being said, the hook has difficulties moving objects.

(Model of Hook Joint)



**Final Design Description:**
For our final design, we have a rectangular frame design to allow for stability when operating the ROV in the water. We also included twice the buoyancy toward the front of the ROV compared to the rear. This is to compensate for the added weight of the hooks and the motors. Furthermore, the two hooks attached to the front of the ROV help with balancing. The two hooks are designed to be able to open the latch during the mission course, as well as displace objects like the new species and sea sponge.

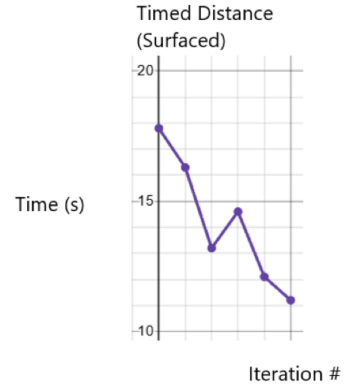
**Scientific and Engineering Terms**:
*ROV* - Remotely Operated Vehicle; "[U]noccupied, highly maneuverable underwater machines" (NOAA).
*Buoyant / Buoyancy* - "Tendency of an object to float or to rise in a fluid when submerged" (Britannica).
*Drag* - "[A]lways opposes the motion of an object… [and] the magnitude of the drag force is found to be proportional to the square of the speed of the object" (Lumen Learning).
*Force* - "[M]aintain or alter the motion of a body or to distort it… The magnitude of the direction is directly proportional to the magnitude of the external force and inverse proportional to the quantity of matter in the body" (Britannica).
*Acceleration* - "[R]ate at which velocity changes with time, in terms of both speed and direction" (Britannica).
*Velocity* - "[Q]uantity that designates how fast and in what direction a point is moving" (Britannica).
*Center of Mass* - "[Represents] the unique point in an object or system which can be used to describe the system's response to external forces and torques" (Nave).

## 4.) EXPERIMENTAL RESULTS

For our testing, we ran two experiments to test the ROV's ability to travel horizontally and vertically using timed trials to verify the effectiveness of our improvements between iterations.

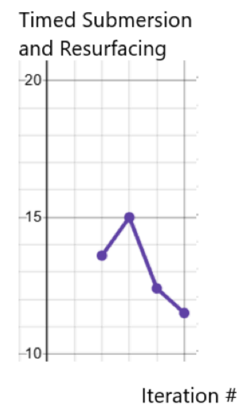
Our first experiment consists of a timed 105-inch runway for the ROV to traverse. The timer begins once the ROV motors start spinning and ends when the ROV touches the wall at the end of the runway.

| Iteration # | Distance Traveled (Horizontal) | Time |
|---|---|---|
| Iteration I | 105 inches | 16.3 seconds |
| Iteration II | 105 inches | 13.2 seconds |
| Iteration III | 105 inches | 14.6 seconds |
| Iteration IV | 105 inches | 12.1 seconds |
| Iteration V | 105 inches | 11.2 seconds |




Our second experiment consists of a 50-inch deep pool for the ROV to sink, reach the ground, and rise back to the surface. The time starts once the motors begin to spin and ends when the ROV breaks water.

| Iteration # | Depth (Lowest point reached) | Time to Reach the Bottom | Time to Resurface | Total Time |
|---|---|---|---|---|
| Iteration I | 1 inch | DNF | DNF | DNF |
| Iteration II | 50 inches | 7.1 seconds | 6.5 seconds | 13.6 seconds |
| Iteration III | 50 inches | 8.4 seconds | 6.6 seconds | 15 seconds |
| Iteration IV | 50 inches | 6.2 seconds | 6.2 seconds | 12.4 seconds |
| Iteration V | 50 inches | 5.9 seconds | 6.1 seconds | 12 seconds |




**Impact of Testing:**

As stated previously in the *Design Iterations* section, for SW6 Iteration I, the ROV could not sink due to its overpowering buoyant force. This detail is reflected in the experimental results through the 1-inch depth and inability to reach the bottom of the pool and resurface since this iteration could not fully submerge. As a result, we decided to reduce the buoyancy in our subsequent designs, allowing our ROV to complete a full submersion.

For SW6 Iteration II, there was a significant improvement in our timed results, but this does not reflect the design's unstable ascension. By reducing the front buoyancy less than the back buoyancy, the ROV did not ascend vertically, resulting in veering.

We attempted to address this issue in Iteration III by shortening the front-to-back length of the ROV. However, this increased the time it took to complete the experiments, so in Iteration IV, we shortened the width of the ROV, successfully decreasing the time it took to complete the experiments.

We noticed that Iteration IV significantly improved in the time trials because of the decreased surface area of the ROV, thus lowering the drag force and increasing the acceleration.

In the final design of our ROV, the center of mass is correctly balanced with the addition of the front hooks to complete the mission course tasks, thus subtly improving the ROV's efficiency in traveling horizontally and vertically.

**5.) REFLECTION AND NEXT STEPS**

Steven Wonder6's approach to the EDP functions with the fundamental pillars that lead to the group's success.

1. ***ASK: Evaluate current ROV iteration weaknesses.***
2. ***IMAGINE: Think of solutions aligned with handling and frame stability.***
3. ***PLAN: Strategize task delegation for efficiency. Leverage team strengths.***
4. ***CREATE: Utilize resources in a competitive ROV.***
5. ***IMPROVE: Iterate through rigorous testing.***

**Reflection**:

The opportunity to participate in a world-recognized engineering competition through undertaking Seaperch has provided all of our team members with both invaluable insights and important lessons to all members of the team. Among few of the many primary lessons that members have gained from Project Seaperch include:

- ***Resilience***: When working on the ROV, team members working on the Seaperch Project must learn to expect a multitude of failures before eventual successes, and to do so, team members must learn the value of resilience and acceptance to focus on refining the ROV, and learn to adapt and overcome new problems as they approach.
- ***Importance of close relationships in the team***: A strong sense of community, understanding, and trust among team members is therefore integral to a solid and functioning team and creates a harmonious working environment among members.
- ***Creative thought process***: Team members often must hone unorthodox methods of thought and creative problem-solving skills to design a high-performing yet unique design for the project's ROV. Through supporting team members to critically analyze and understand every function of the project, Steven's Wonder6 fosters a dynamic that foremost encourages the virtue of innovation for all members working on project Seaperch.

**Next Steps**:

As all of Steven Wonder6 consists of exclusively senior members, Project Seaperch will be the last the team will work together, but this is not the end of our journey. For our team, we will use the valuable lessons we learned to extend into our future career paths. Our ROV serves as an important symbol of our hard work and dedication as a team and we will continue to treasure this experience as we graduate from high school. In the coming months, each member will embark on their unique journey and represent the team's continued success in the future.

- **Damian Garneri** plans to enter the military after high school and pursue a career in education, using the skills of *collaboration* and *resilience* to succeed in his plans.
- **Corey Khy** plans to pursue a career in engineering after high school after attending university, using the skills of *creative* and *critical thinking*.
- **Thuan-an Duong** plans to attend university and obtain a degree in biomedical engineering and pursue a career in that field, using the skills of *creative thinking* and *resilience*.
- **Steve Velazquez Jr.** plans to attend university, obtain a mechanical engineering degree, and pursue a career in that field, utilizing the *leadership skills* he gained from Seaperch.

**6.) ACKNOWLEDGMENTS**

No matter the size or profession, even if united in thought and goals, a group without the proper guidance or backing from those around them, innovation and cohesion as a whole would adamantly and exponentially become harder to achieve. Therefore, along with the deepest of appreciation, our team must thank the following for their considerable contributions:

**Paloma Valley High School**, for the extensive financial backing needed for the materials and for allowing our unorthodox team to use resources further to participate in this extensive project. It has been our great privilege to represent our school as we compete in a world-recognized endeavor.

**Mrs. Sandra Arugello,** whose guidance and unending support in our team made participation in the Seaperch challenge possible.

**Darren Luu,** for aiding in the designing and modeling of the connectors for the hooks on our ROV and for allowing us to use his 3D printer on such short notice.

Finally, this process would never have been completed without **each of our team member's parents,** whose constant support and encouragement allowed us to endure the struggles and exhaustion when pursuing the journey of innovation.

**7.) REFERENCES**

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**Budget**

| Component | Vendor | How Was the Component Used? | Total Cost of Item |
|---|---|---|---|
| 2 oz of 1.75 mm filament | AliExpress | To 3D print 3 motor mount parts. | $0.48 |