Diving Into Disaster:

An Innovation Project

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Abstract

This project investigates how a SeaPerch underwater remotely operated vehicle could be used to support post-disaster assessment and underwater search and rescue operations in our community of Muskegon, Michigan. The project was selected due to the significant damage floods cause to infrastructure and civilians, much of which poses a significant risk and danger when quickly assessed by human divers after a major event. Submerged debris and poor water visibility create hazardous conditions that delay recovery and increase risk to human lives and resources.

Our objective was to design and test a student-built ROV capable of operating in simulated post-flood conditions to inspect underwater hazards and infrastructure. We hypothesized that a SeaPerch ROV could provide a safe, low-cost, and effective method for conducting initial underwater assessments in shallow and low-visibility environments. Using the engineering design process, we built, modified, and tested an ROV optimized for stability, maneuverability, and visual inspection.

Testing demonstrated that the ROV was able to navigate obstacles, maintain control, and capture underwater imagery in conditions similar to those expected after a large flash flood. The results support our hypothesis and show that SeaPerch technology has real-world potential for disaster response applications. This project highlights how student-designed underwater robotics can be adapted to address real environmental challenges and contribute to safer, more efficient natural disaster recovery efforts.

Background & Motivation

In the local community of Muskegon, including housing districts and infrastructure, the area is prone to many kinds of flooding catastrophes, such as flash floods. The latest account of flash flooding in Muskegon County took place on May 17, 2020. While this event caused no significant losses, in case of future emergency, we are more than willing to prepare community resources in order to take deliberate action.

Our project aims to explore how SeaPerch underwater remotely operated vehicles could support post-flood assessment and response in environments such as Muskegon's many rivers and coastal waters (Figure 2), and potential submerged city infrastructure. As seen in Figure 1, a 2024 weather-related disaster study, floods are one of the most fatal natural disasters. Among those fatalities are the first responders who risk their lives to serve the community and its citizens.

SeaPerch ROVs are cost-effective, modular and capable of operating in shallow, obscure conditions that are common after significant flooding takes place. By using imaging sensors and maneuverable controls, SeaPerch robots can be deployed to inspect submerged infrastructure, locate debris fields, and map underwater hazards, reducing risk to human divers and speeding up the initial survey process.

This work is important because rapid underwater evaluation after a large flood can improve decision-making during recovery operations. Conditions that search and rescue divers may face could lead to a substantial risk in their lives, such as diving through windows, navigating houses under the water, and other encapsulating environments may lead to danger of getting stuck, injured, or failure to rescue on a mission. The use of an ROV would reduce this risk by providing intelligence and minimizing the chances for failure.

Figure 1

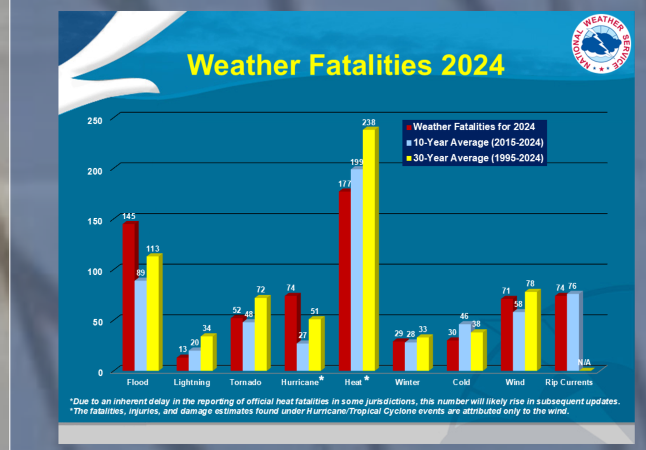
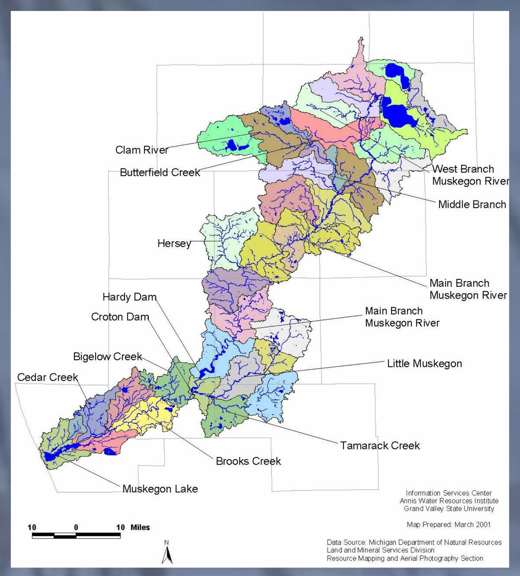


Figure 2



*Breakdown: The Design Approach

Frame:

Through excessive research, we crafted a frame that is both hydrodynamic and lightweight, yet durable (Figure 3). Our goal was to touch on every ideal attribute, making a balanced design. A mix of freehand, researching, and trials, we decided upon a pentagonal structure.

This design supported speed, structural integrity, and additions such as the camera and lights. We tested thoroughly through processes such as hydrodynamic testing, low-visibility pool navigation, and durability testing.

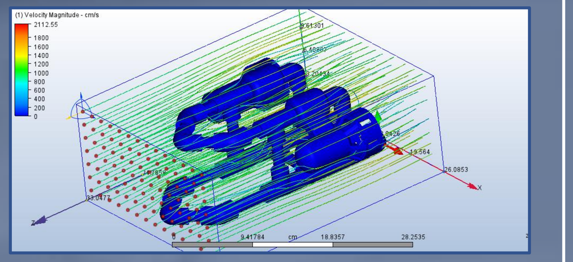


Figure 3

Camera:

By experience, an ROV gets rather difficult to maneuver when completing tasks throughout the mission course as the ROV gets farther away from the driver. This is because visibility decreases, and the driver becomes less alert of the ROV's positioning and movements.

A camera would work to minimize gaps in the driver's skill as the ROV gets farther away and less visible to the driver (Figure 5). The camera is supported by the frame as it supplies a good vantage point for the camera to be placed in order to maximize visibility and use (Figure 6). The camera is connected through wiring, and displays onto a screen that can be accessed by the driver if they stand within viewing proximity (Figure 4).

Figure 4

Figure 5

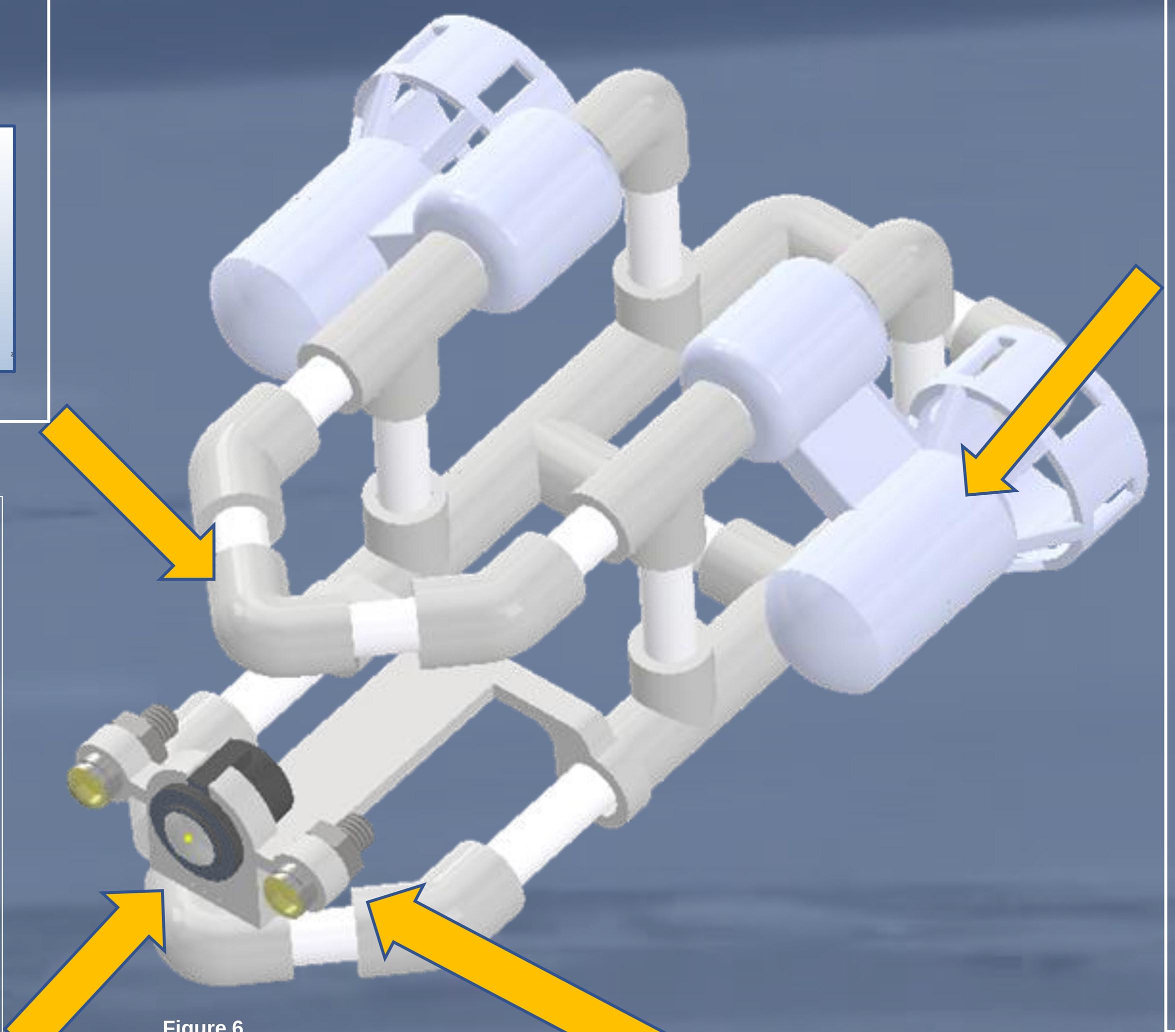
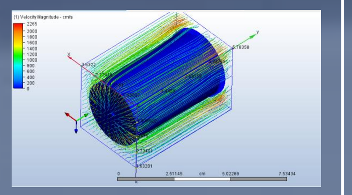


Figure 6

Motors:

The default design for motors, film canisters, is not as hydrodynamic as we had hoped (Figure 7). We had realized that flat surfaces significantly minimize the fluidity in which water passes over and around an object. In fact, the shape of an object has much to do with its property of laminar flow.

Figure 7



We conducted 2 tests of what would work to solve this issue.

Test 1: (Figure 8)
Sharp, Missile-like motor holders.

These proved better than flat. We were happy with the improvement, but growth could still be made.

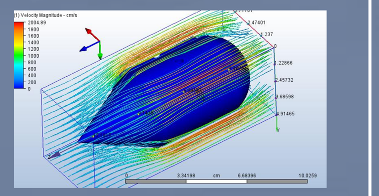


Figure 8

Test 2: (Figure 9), (Figure 10)
Rounder, dome-shaped motor holders.

These were better than the flat and the sharp motor holders. We decided on this shape due to its optimal weight and laminar flow.

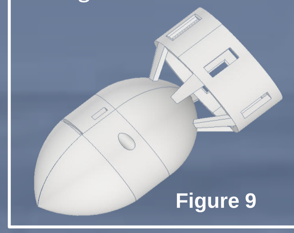


Figure 9

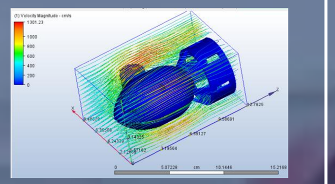


Figure 10

Lights:

The implication of LED lighting would increase visibility when utilizing the camera (Figure 11). In foggy, murky, deep, or otherwise difficult conditions, the ROV can be practically invisible and rather hard to navigate. Also, the camera would have less usability if the driver is unable to see anything from it.

LED lighting is a waterproof solution to the visibility problem. Positioned on the front of the frame, the lights would help to clearly identify the front end (Figure 6).. The camera would have enhanced visibility, with the lights leading the way through low-visibility environments.

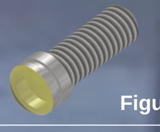


Figure 11

Conclusion

The objective of this project was to create an ROV design that could be used to efficiently and effectively investigate underwater wreckage and navigate through debris to assist first responders in their search and rescue missions post-catastrophe. The use of this ROV would allow responders to safely search underwater infrastructure in order to minimize the chance of accident, and better gather information remotely before risking human lives. Using the Engineering Design Process, the ROV was tested to navigate an obstacle course, simulating the dodging and navigating of debris, proving it useful in a realistic scenario. Many trials and design changes were made in order to optimize functionality of the ROV. The design was created to be more hydrodynamic and agile through the use of 3D printed parts and natural buoyancy, reducing drag and allowing for a more effective design in case of part failure. The design was also articulated to be able to lift objects and transport them. Through the use of an ROV objects or people could be discovered and maybe even recovered from a remote and protected location. Our eventual hope for our project is that it will be applied within our own community and be utilized as a method to protect our first responders and encourage the use of new technology, to make the world a better, safer place.

Methodology

Our project followed an engineering design process focused on solving real-world problems caused by floods in our community. We began by researching the impacts of the Muskegon Flash Floods of 2020, specifically how flooding affected underwater infrastructure such as local habitat preservation, the natural food chain, and housing in the region, including people and properties. This research identified the need for a safe, low-cost method to inspect underwater damage under low-visibility conditions, and inspired us to create a beneficial impact on our community.

Next, we designed and built a SeaPerch underwater remotely operated vehicle (ROV) optimized for post-flood assessment. Our initial approach focused on basic maneuverability and stability; however, as the project progressed, we modified our design to improve control in simulated rough and turbid water. These changes included adjusting thruster placement, reinforcing the frame, and improving cable management to reduce drag.

We theorized multiple approaches in a final, idealized design that we hope to eventually create in the future.

The materials currently used in this project include PVC piping for the frame, electric thrusters, a tethered control system, waterproof wiring, LED lighting, and an onboard camera for visual inspection. These components were selected to balance durability, affordability, and performance.

*Components of our design are further elaborated in the "Breakdown" section

Acknowledgements

We would like to credit many of our motivations and inspirations for this project to the following individuals:

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- Reeths – Puffer High School – For donations and your boundless support

This project could not have been possible without their guidance, and our gratitude could not be put into words.

Our research was collected from a plethora of sources:

- https://www.weather.gov/grr/04302020_HeavyRain_LakeshoreFlooding
- https://www.mlive.com/galleries/5IZ7DWU7AVFNZNERQSG2U6O6QU/
- https://www.mlive.com/news/muskegon/2020/05/west-michigan-residents-face-catastrophic-flooding-after-record-breaking-rainfall.html
- https://fruitlandmi.gov/wp-content/uploads/2021/11/E-News-05-20-20-Press-Release-Flooding-State-of-Emergency.pdf
- https://co.muskegon.mi.us/List.aspx?MID=15
- https://www.wzzm13.com/article/news/local/muskegon/fisherman-rescued-on-muskegon-lake/69-74a04cb3-b849-4502-a21a-37093a5d82df
- https://seaperch.org/

Next Steps

The next steps for our project are ones of great magnitude. Our essential goal is to eventually get into contact with the first responders and agencies in our area and put ROVs into action to hopefully assist in protecting the lives of those in our community in the case of another flooding emergency (Figure 14).

We would like to eventually establish a partnership with the Muskegon area fire department and help the to design an ROV which could be of use to them when they carry out underwater rescue missions. We have put an effort forth on many occasions to communicate with our local fire department, even taking a visit and speaking to them in person 2023 (Figure 13), but they have failed to consistently get back to us with information.

The team has worked on adapting our idealized design into physical form (Figure 12), but we have had certain human input errors such as measuring the proper lengths of PVC components and generating ideas for a hook tool design, which have proved to be obstacles in our drive to optimize the ROV. With that, we are still quite happy with our current progress and will continue to improve on the design as we continue to pursue a potential relationship with the Muskegon County Fire Department.

Figure 12

Figure 13

Figure 14