The Bull v3

US Naval Sea Cadet Corps – Escondido Battalion

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SEA PERCH DESIGN

The Bull underwent design modifications over the past 3 years to better meet the tasks of the ROV obstacle and challenge courses by addressing the following:

1. Reduce weight and size to increase speed and agility
2. Modify frame design to make it more hydrodynamic
3. Design retractable challenge features for efficiency in both courses
4. Improve buoyancy and trim through alternative methods
5. Waterproof and stabilize motors
6. Improve tethering system
7. Consider best color for underwater visibility

The Bull v1

THE BULL V1– 2014

Built from the stock kit this version was quickly assembled and stable, but had several drawbacks:

- Frame was boxy and caught on the obstacle hoops
- Motors had short life spans due to water infiltration
- Pool floats became waterlogged and lost buoyancy.
- Netting was unnecessary and created drag

The Bull v2

THE BULL V2– 2015

Modifications to the stock kit included:

- Angling the front corners to ease travel through hoops
- Removing the netting to reduce drag
- Replacing open-cell pool floats with closed-cell Styrofoam and placing them within the frame
- Notched PVC frame to firmly seat motors
- Enclosing the motors in PVC casings for waterproofing
- Creating a retractable finesse hook.

The Bull v2 had a 4th place obstacle course finish at the 2015 National Finals with a time of 41.37.

However, problems included:

- Motors continued to waterlog, were too heavy and time-consuming to build
- Tether tangled and became waterlogged
- Frame still too boxy

The Bull v3

THE BULL V3– 2016

Registration in the open class allowed creative freedom. Changes included:

- Using flexible lightweight PEX pipe to create streamlined bow front frame.
- Replacing approximately 50% of the frame with PEX to reduce weight.
- Sealing the top part of the box with air for buoyancy, ballasting the vehicle by drilling holes in the bottom half of the frame.
- Creating collapsible netting cage for dual purpose in obstacle course and orbs challenge course.
- Sealing motors in Flex Seal spray rubber sealant.
- Stripping tether of plastic sheathing and replacing it with braided expandable sleeving to make it more supple and porous and to reduce corrosion of copper wires within.
- Maintained RED color of the PEX pipe to aid in underwater visibility.

seaperch TEACH • BUILD • BECOME

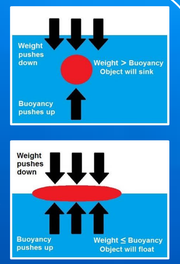
Technical Specifications:

- Total dry weight – 25 ounces
- Height – 6”
- Length – 12”
- Width – 7.5”

DESIGN ENGINEERING CONCEPTS

FRAME

In order to reduce **MASS**, and thereby reduce the necessary buoyant force needed to maintain **NEUTRAL BUOYANCY**, we replaced about 50% of the frame with PEX as it’s lighter than PVC. A box frame was retained for its stability, but was made smaller and shorter in order to reduce voulme and ultimately reduce **DISPLACEMENT**.



http://www.thestargarden.co.uk/Force-and-energy.html

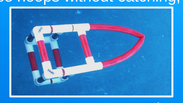
COLOR

We maintained the RED color of the PEX pipe for VISIBILITY in the water.

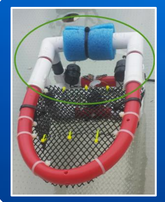
PEX – Crosslinked (X) Polyethylene

HYDRODYNAMICS

In order to create a more **HYDRODYNAMIC** shape that travels through the obstacle course hoops without catching, we designed a bow front using flexible PEX pipe.



First attempts to create our bow resulted in bent pipe. Heat application warmed the pipe enough to create the desired shape.



STABILITY

To stabilize the frame and to add internal **BUOYANCY**, we made the top PVC part of our frame airtight and drilled holes in the bottom half to provide **BALLAST** and **VENTING**. A small piece of pool float was attached to the back of the frame and holes were drilled into the bow front to **TRIM** the unit and keep it level. To keep water from entering the PVC part of the frame from the vented bow front, we plugged the ends of the PEX tubing with wooden plugs and adhesive before inserting them into the PVC frame.

MOTORS

Past experiences with waterproofing the motors were successful but time-consuming. We wanted to achieve similar results using a quicker method. We decided to use Flex Seal, a spray-on latex sealant product that’s marketed to coat, seal and stop leaks. The results were equal to prior waterproofing methods and had the added benefit of producing a smaller, lighter motor.

NETTING

The bowed front provided both a hydrodynamic design and a wide frame for the netting cage that we needed for the orbs challenge. In order to keep a streamlined design for the obstacle course, we chose to create a collapsible cage. Reusing netting from old kits, we folded in the sides and zip-tied them to the back of the cage. For the orbs challenge we removed the zip-tie at the back, opened the sides and then re-zip-tied them along the top of the bow frame, thus creating a cage to capture the whiffle balls.

TETHER

The original Cat 5 plastic sheath resulted in eventual corrosion to the wires by trapping water through **CAPILLARY ACTION**. To solve this, we stripped the plastic sheathing off the original tether, removed the non-essential brown wire to reduce weight, and re-sheathed the remaining wires with braided expandable sleeving. The braided sleeving allows moisture to evaporate from the wires, helps keep the line from tangling, and produces a smooth, sleek surface that reduces snagging. The flexible construction of the sleeving is meant to go through small spaces and around tight turns.

KNOWLEDGE GAINED

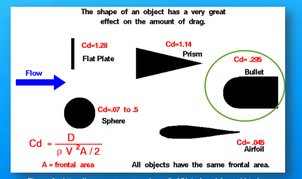


Figure 1 - https://www.grc.nasa.gov/www/k-12/airplane/shaped.html

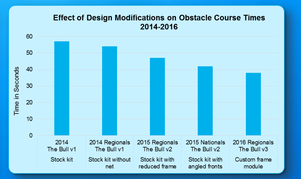


Figure 2

All the changes made through the years had the primary goal of reducing mass and volume of the Sea Perch in order to increase speed, reduce the buoyant force needed to maintain neutral buoyancy, and to increase hydrodynamics.

Archimedes Principle states that an object immersed in fluid will be lighter by an amount equal to the weight of the fluid it displaces. This upward force exerted on the object by the fluid is known as the buoyant force:

$$FB = g\ pF\ V$$

Where FB is the buoyant force on the object, g is the acceleration due to gravity, pF is the density of the fluid, and V is the volume of the object immersed in a fluid.

We achieved these goals by reducing the volume of the frame by making it smaller and reducing the mass by making it lighter. Additional consideration was given to the shape of the ROV. Early versions of The Bull were boxy in shape and produced too much drag. A bullet shape (figure 1) was chosen for its smaller drag coefficient, making the Perch more streamlined.

The chart above (figure 2) shows the effect of changes to our frame design through the years which resulted in making the Perch faster and more hydrodynamic.

TEAM MEMBERS

FISCHER MATA (JUNIOR)

- Team Captain; Driver; Chassis Build & Design
- Skills: Leadership, Basic Engineering Skills, Tenacity
- Sea Cadet for 3 years – Petty Officer 1st Class and LPO
- Member of High School Robotics Team and Sea Cadet CyberPatriot Team
- Intern for California State Senator Joel Anderson
- Owns business EZ DOGGZ and works on his 1956 Chevy Bel Air in his spare time

LUKE VORE (FRESHMAN)

- Tether Handler, Researcher
- Skills: Public Speaking; Competitiveness, Fearless
- Sea Cadet for 2 ½ years – Petty Officer 2nd Class
- Member of Sea Cadet CyberPatriot Team
- Swims on High School Varsity Swim
- Athlete/Scholar on the high school honor roll