The Water Dogs – RoboBoat 2017

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***Abstract*—This document describes The Water Dogs' entry to the RoboBoat competition. Topics in this document include: the vehicle name, the overall strategy to accomplish the competition tasks, the design process of our boat, and the software development process. Hardware that we will be this year includes: a autonomous robotic boat, impeller thrusters, and hydrophones. There was a strong focus on outreach to spread STEM throughout the community.**

I. Introduction

All members of the Water Dogs RoboBoat team are part of a larger robotics club that makes them well rounded in STEM and robotics. The club competes in many Robotics competitions including: the DIDI 500, SECME, Mini-Urban Challenge, VEX Robotics Competition, and FIRST Tech Challenge. DIDI 500 is a car based competition that requires a renewable energy source to power the car. Our members won the Industry Favorite award at the annual MAF summit. SECME is a collection of STEM-related challenges, with a main focus on water rocketry, in which our participants claimed a national title. The VEX Robotics Competition is a season long engineering challenge in which teams must build and program a robot which performs tasks. Mini-Urban Challenge is a fully autonomous Lego Mindstorm competition in which robots must self-navigate through a model city, being similar to the autonomous focus of the RoboBoat competition. The FIRST Tech Challenge, the club's most time consuming and successful event with a strong focus on outreach and documentation. The club recently achieved a second place finish at the World Championship in Houston. Nine of our twelve members of the Water Dogs have programming experience. All these previous experiences have given us the skill-set to tackle this new challenge, bringing robots to the water.

A. Mentoring

The Water Dogs are grateful for their mentor, Mr. Don Harper, for providing his knowledge of computer science and robotics. He competed in the DARPA Urban Challenge, which focused on autonomous vehicles. Aside from robotics, his most notable hobby is sailing, giving him the nautical knowledge needed to lead the Water Dogs into this competition.

II. Design Strategy

Because software is the main focus of this competition, a balanced platform is required in order to have accurate sensor readings. Therefore, the Water Dogs chose a catamaran hull over a monohull design due to its stability and mobility through the water.The instability of a monohull design was not conducive to the team's goals while the catamaran proved optimal. The team ultimately decided on valuing a steady design over a speedy one. In order to test this idea, The Water Dogs experimented with different hull designs and tested the pros and cons of each as shwon in Figure 1 and Figure 2, in order to draw the conclusions for what design would be best. The experimental variables included weight to thrust ratio, load capacity, and overall stability. We found that the catamaran design proved optimal for most of these categories and therefore Sir Docks-a-lot's design is based on it.

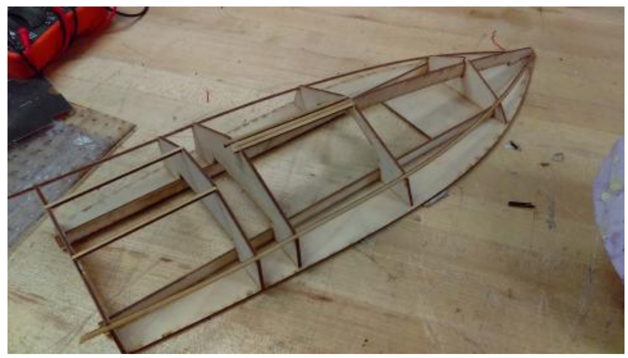

Fig. 1. *Prototype monohull design laser cut and assembled out of plywood.*

Fig. 2. *Catamaran boat prototype made out of insulation foam.*

A. Programming

The Water Dogs plan on using the Robot Operating System (ROS) which provides the skeleton for all of the team's software systems. Using ROS, modules can be made for each boat subsystem. For example, the team is currently working on a ROS module that will encapsulate the functionality of the Modern Robotics Servo Controller. The team uses this controller in the FIRST Tech Challenge, and by wrapping it in a ROS module, the team is able to integrate it into the boat system. ROS also allows for synergy between sensors including lidar, stereo vision, and an Android Moto G4 Play camera.

The Lidar the team plans to use is a SICK TIM551-2050001. This is an infrared sensor with a scanning angle of 270 degrees at 15 Hz. The angular resolution of one degree should make sure the team has a number of returns from the fixed buoys.

Fig. 3. *SICK Lidar sensor used to detect buoys.*

III. Vehicle Design

The Water Dog's previous experiences have taught them the importance of utilizing CAD first before building or manufacturing. The members have a background in PTC CREO, which helped in the transition to using new CAD programs such as Orca3D,a plugin of Rhinoceros, and Autodesk123D Make. The team used Orca3D in order to design the basic structure and geometry of the hulls. Utilizing this program, allowed the team to make quick modifications to the design based on experimental results. For instance, the Water Dogs were able to adjust variables like dimensions in order to achieve the proper proportions to support the estimated weight as shown in Figure 4. An interesting feature of Orca3D is that it shows the predicted load line based on the dimmensions of the boat as shown in Figure 5, which proved useful in designing the shape of the hull. Additionally, the team used Autodesk123D in order to hollow out and slice up the hull into parts which can be manufactured via a laser cutter as shown in Figure 6 and Figure 7. The team has experience in laser cutting, which they utilized extensively in the FIRST Tech Challenge. Laser cutting has proven the fastest and cheapest way to bring the team's ideas to life.

To provide thrust, Sir Docks-a-lot comprises of two Alien 6355 Outrunner brushless 230KV 2400W motors from Alien Power Systems as shown in Figure 8, with one on either hull. The team used the OpenProp software from Dartmouth to design the propellers which will later be 3D printed.

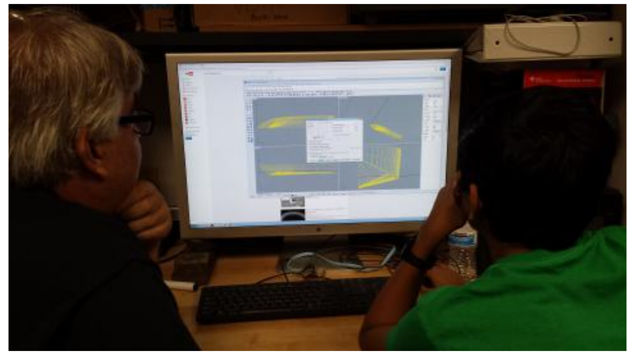

Fig. 4. *Water Dogs member Neel and mentor Don Harper modify the hull's dimensions in Orca3D.*

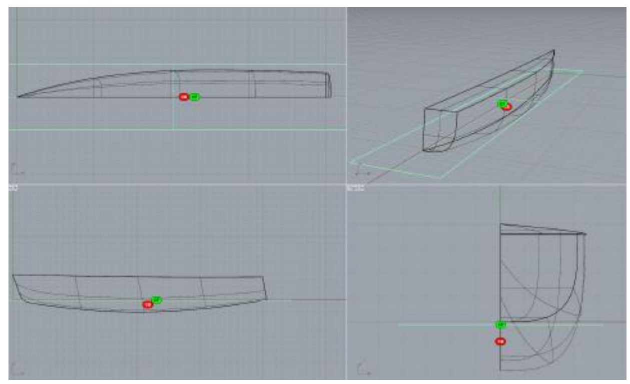

Fig. 5. *Finding the buoyancy line on the hull of Sir Docks-a-lot using Orca3D .*

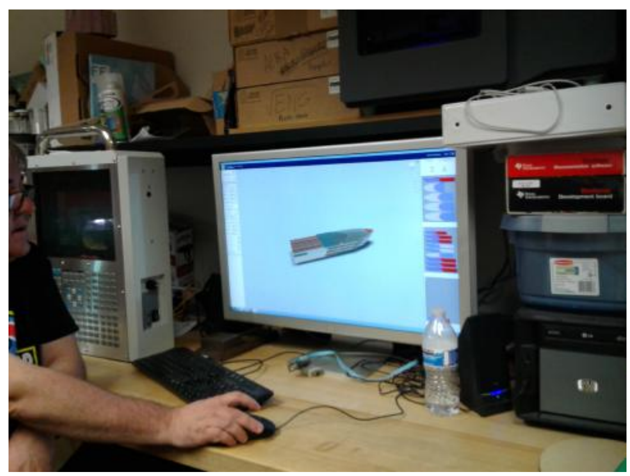

Fig. 6. *Water Dogs mentor Don Harper shows team how to use Autodesk123D Make.*

The final dimensions of the hull are 48X9X12 inches with an approximate load capacity of 25 lbs, found from weighing all components and sensors.

IV. Experimental Results

To test the different boat hull designs that could be used, several foam prototypes were made. First, three small scale boats of roughly 318 grams, using insulation foam. The first

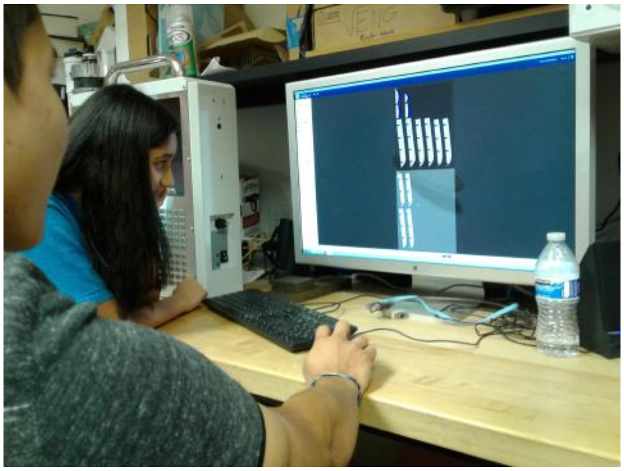

Fig. 7. *Water Dogs members Nico and Aashni work on slicing the hull in Autodesk123D Make.*

Fig. 8. *Alien Power Systems Brushless Motor*

design was a V-hull design meant to reflect most modern day speed boats. The V-hull provided the most speed, but the least load bearing capabilities and the least stability. The second design was barge, with a flat bottom. It placed first in load bearing capabilities, but last in speed and second in stability. The third design consisted of a catamaran hull. It seemed to perform the best in the categories most crucial to the competition, which is stability and speed, placing first and second in those categories respectively. It also placed second in load bearing capabilities making it the most desirable design overall.

A. Speed Experiment

In order to test how quickly each boat could travel through the water, we designed a controlled experiment. A pool contained the experiment, as to eliminate weather and current effects. The same motor and battery was connected to each boat in order to maintain consistency. We then timed each boat as it traversed the length of the pool. We repeated the process three times and took an average. The times are recorded in the table below.

Speed Experiment				
Trial	Time of V-hull Boat to cross 10 met	Time of Barge Boat to cross 10 me	Time of Catamaran Boat to cross 1	Distance (meters)
1	24	42	32	10
2	23	40	34	10
3	25	42	33	10

Fig. 9. *Table containing results of speed experiments.*

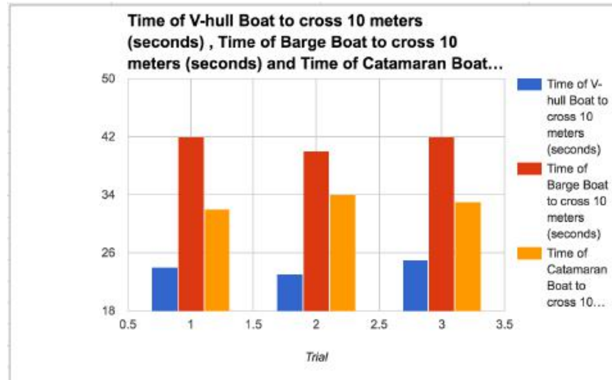

Fig. 10. *Graph of speed test data.*

B. Load Bearing Capabilities

Using the same setting as the previous experiment, each of the boats were placed in the water and weights were added to the middle of each boat until it was submerged. the data is represented in the table below.

Load Bearing Capabilites			
Trials	V-hull Boat Max Weight (grams)	Barge Boat Max Weight (grams)	Catamaran Boat Max Weight (grams)
Trial 1	54	102	79
Trial 2	57	101	81

Fig. 11. *Table of the data from the tests of the load bearing capabilities of the test boats.*

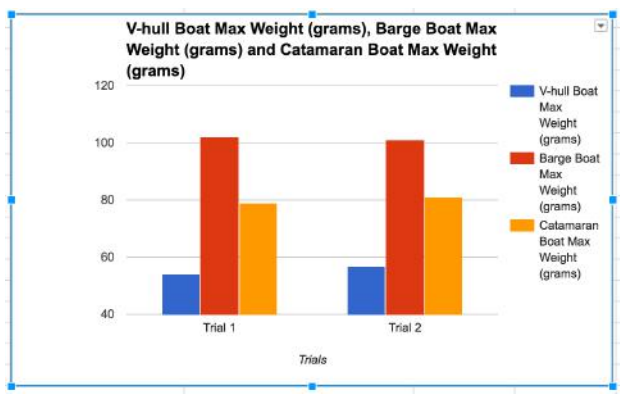

Fig. 12. *Graph of the data from the tests of the load bearing capabilities of the test boats.*

C. Stability

The boats from the previous were placed in the water. The weights from the previous experiments were stacked one at a time on the far side of the boat until the each boat capsized. The experiment was repeated three times, and the data is recorded below.

Stability			
Trials	Max Weight to Tip a V-hull Boat	Max Weight to Tip a Barge Boat	Max Weight to Tip a Catamaran Boat
1	33	45	59
2	32	44	58
3	34	46	61

Fig. 13. *Table of the data from the tests of the stability of the test boats.*

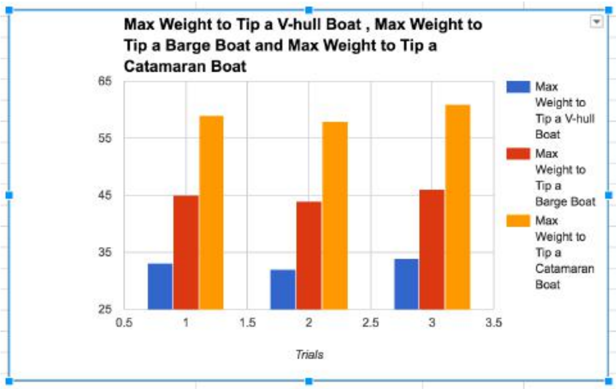

Fig. 14. *Graph of the data from the tests of the stability of the test boats.*

V. Outreach Activities

Because the Water Dogs are a community-based team with a background in FIRST competitions, a heavy emphasis is placed on Outreach activities. The team has done 22 hours of outreach this year. Our events include demonstrating Sir Docks-A-Lot in Lake Pickett, talking to students about the importance of STEM activities, and spreading the word about our robotics club. All team members are required to participate in outreach events to ensure that the work is shared equally. Before each event, the team meets to discuss and review the content being presented so that each member will understand the material and be able to teach others. Figures 15 - 17 are some pictures from various outreach events.

Fig. 15. *Water Dogs member Matthew greets Ashley Sherman, the Orlando Cyborg.*

Fig. 16. *Water Dogs members Neel and Aashni help demonstrate emerging technology at a local Barnes and Noble along with mentor Mr. Harper.*

Fig. 17. *Members of the larger robotics club support the Water Dogs by helping at a team carwash.*

VI. Conclusion

For the most part, the boat design has been finalized and the remaining time will be spent on improving software. The team hopes to experiment more with the Android Moto G4 Play camera in addition to OpenCV, in order to more efficiently navigate the course. The team has experimented with this software in the past to detect colored balls, so they will have to adapt this algorithm to colored buoys. Overall, the Water Dogs have become well versed in Orca3D, Autodesk123D, and continue to test with ROS.

VII. Acknowledgements

Special thanks to all our kind sponsors listed below in Figure 18. None of the Water Dog's accomplishments would be possible without their contributions. Also, special thanks to the coaches, Mr. Stefan Ibarguen and Mrs. Po Dickison for all their hard work and support. Again, the team would like to acknowledge Mr. Don Harper for all his time and knowledge.

Fig. 18. *Generous sponsors of the Water Dogs*

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