Autonomous Surface Vehicle

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Abstract

The objective of our Autonomous Surface Vehicle is to compete in the annual ASVC, Autonomous Surface Vehicle Competition, held every year in June at Founders Inn Resort in Virginia Beach. The Mechanical Engineering team handles the design and construction of the structural frame, boat hull, and mechanical components. While the Electrical and Computer Engineering team handles the electronics, programming, and control systems. The competition has us compete against other universities and colleges from around the globe and requires our vehicle to complete various tasks and meet various requirements. These requirements include weight and dimension constraints, under 140 lbs and under 3x6x3 respectively. Then the ASV must perform tasks such as object recognition, avoidance, and navigation around buoys that mark the course.

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Introduction

An Autonomous Surface Vehicle is a boat that can navigate, complete its tasks and operate by its self without any human input or intervention. The purpose of this project is to design and fabricate such a vehicle that is to be entered into the international ASV competition held in Virginia Beach, VA on June 2011. In this contest teams from Universities from around the Nation and world must design and build boats that can perform key tasks that have been outlined by the competition guidelines. Among these key tasks are a speed test, thrust test, and navigation an obstacle course made of red, green, and yellow buoys. Also part of the competition are four sub tasks made of identifying a single target from others by temperature, aiming water cannon to hit a specific target, object retrieval from land, and navigation under a water fall.

The ME senior design project team, will work in collaboration with students from the ECE department to build a boat that can satisfy these requirements. The principle duties of the Mechanical Engineering team consist of the design and construction of the frame, pontoons, cart, and motors, in addition to the design and layout of the electrical box. Additional tasks that fall under the main tasks are the mounting of cameras, GPS, compass, and any device that helps complete one of the subtasks also are the responsibility of the Mechanical Engineering team. The Mechanical Engineering Team also took charge of the Coding of the ASV's logic, vision, and object detection systems. Lastly testing of the boat is also the responsibility of the Mechanical Engineering team, tests that map the capabilities of the boat have to be evaluated to determine the final programming and responses of the boat.

1. Competition Guidelines

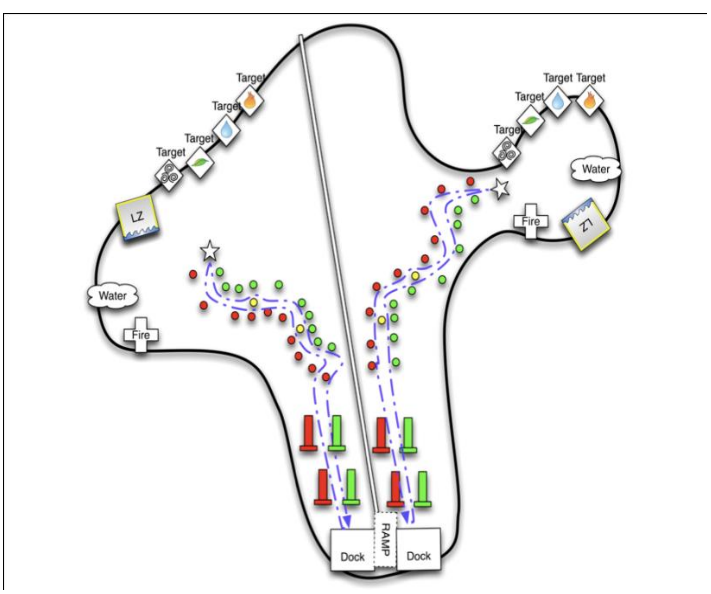
1.1 Overall Requirements

Overall requirements are requirements that every team's boat has to conform to, such as the size of the boat, the weight of the boat, and special requirements such as a cart to lower it into the water. For this year's competition all boats must be remote controlled and have a kill switch in case something goes wrong. During the run communication with the vehicle is strictly forbidden with the exception of the tasks that require the retrieval of a GPS location, or confirmation of a target. The dimensions of the boat are not to exceed 3 feet by 3 feet by six feet, while the weight of the boat is not to be greater than 140 lbs. Every boat is also to have a cart or trailer to lower it down a ramp and into the water.

As of April the competition guidelines were updated to include a penalty for boats above 110 lbs and to disqualify boats above 140 lbs.

1.2 Main Competition Tasks

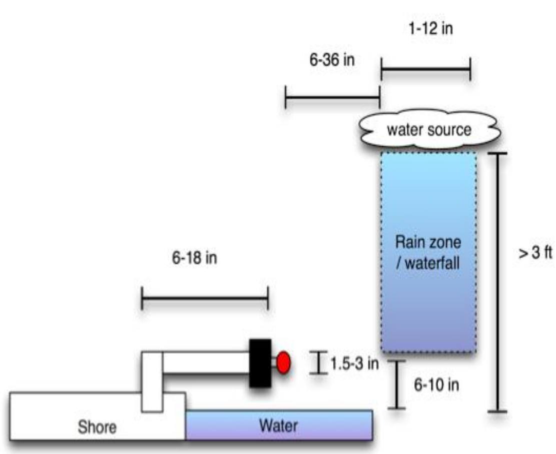
There are three main mission tasks that all boats are graded on that make up the bulk of the points for the competition. Among these tasks is a demonstration of the strength of the boat. Here each

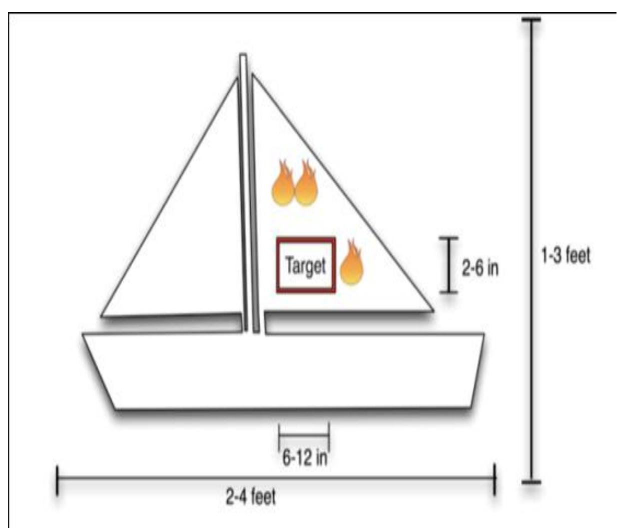


boat is hooked up to a thrust measurement system. Each vehicle then tries to generate as much thrust as possible in 10 seconds. Each team has to provide a harness so that two points on the vehicle can be attached to the strain gauge. The second main task is the demonstration of the boats speed, here the vehicle leaves a starting gate and navigates a steady strait course to a speed gate where the time it takes to get from one to the other is then recorded. The last major task is "navigation out of the harbor" here each boat navigates a course of red, green, and yellow buoys. The red and green buoys serve as gates were the boat has to navigate a winding course between each set while occasionally avoiding obstacles represented by yellow buoys.

1.3 Subtasks

In addition to the three main tasks there are four challenge stations to be completed for bonus points. The first and hardest of the four is the amphibious landing station where the boat has to retrieve an object from land. The second task is to find and fire and extinguish it. In this task the boat has to locate a mock up of a boat that has an elevated temperature from its surroundings. The vehicle must then use a water cannon to spray enough water at a specific target on the boat to "extinguish" the fire. Object detection and identification serves as the third task, here the boat must locate four targets designated by elemental symbols and determine which one has an elevated temperature and thus denotes the fire symbol. The final task has the boat navigate under a waterfall and locate a switch to deactivate the waterfall.





1.4 Scoring

Table I: Static judging scoring sheet

Subjective Measures	Max. Points
Utility of team website	50
Technical merit (from journal paper)	50
Written style (from journal paper)	50
Technical accomplishment (from static judging)	75
Craftsmanship (from static judging)	75
Team uniform (from static judging)	10
Discretionary static points (awarded after static judging)	40
Total	350

Table II: Performance judging scoring sheet

Performance Measures	Max. Points
Weight	See Table I
Generate F pounds of thrust (thrust measurement lbs)	(F / weight) * 100
Pass through the starting gate	100
Navigate from Starting to the Speed gate in T seconds	250 - T
Enter navigation channel	50
Navigate through X buoy set in the channel	X x 50
Avoid N obstacles in the navigation channel	N x 100
Earth station	3000
Air station	500
Fire station	1000
Water station	1000
Be the only team/vehicle to attempt a challenge station (bonus) *	500
Return to dock	500
Finish All Tasks with T minutes Left on Clock (whole + fractional)	T x 100

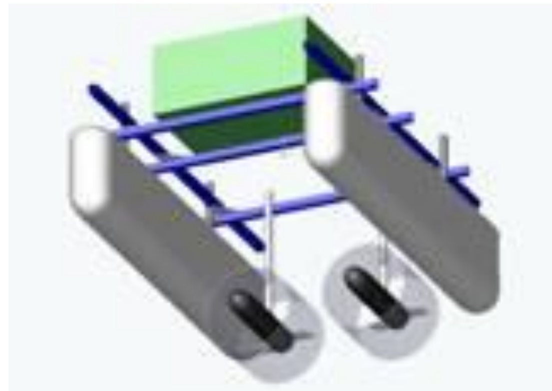
2. Assessment of Previous Year's Boat

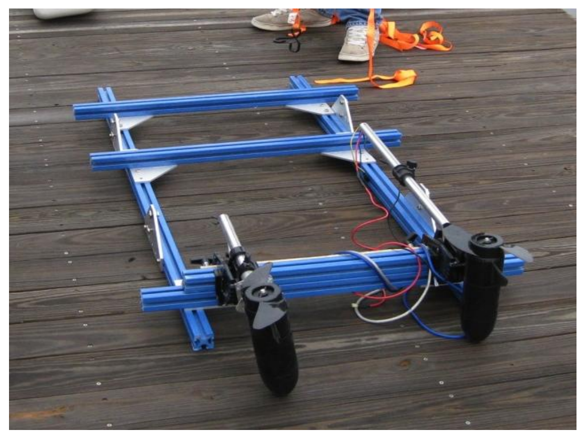
2.1 Design Changes

The starting point of our project was an evaluation of last year's boat. Last year's boat featured a hull made of a single sheet of aluminum that was bent for form the shape of two boat hulls and contained a space inside for the electrical components. In addition, the boat featured a single motor, water jet thrusters for steering and maneuverability, a single camera, and a robotic arm for retrieval of a large ring from last year's competition. Necessary changes were decided upon that the water jets used for maneuverability were too weak as was the use of only one motor. The aluminum hull caused interference with the electronics, specifically the compass and GPS. Finally a single camera didn't provide the field of vision necessary, which frequently resulted in the boat getting lost and wandering off course. The decision was made to try for a modular hull to allow for flexibility, two motors for better turning and power, and a minimum of two or three cameras.

3. Boat Structure

3.1 Frame

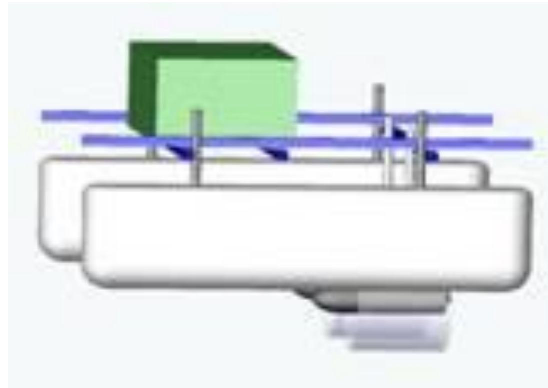




Going off of last year's boat it was decided to go for a modular hull that featured two large pontoons for stability and provide for a solid platform. Seeing as the preliminary competition requirements were posted in January every year we had to build a hull that allowed for components to be easily moved around and adjusted in the anticipation that more equipment would be added to the boat later. This concept led us to the use of fiber glass beams that had channels pre cut into them, so that aluminum brackets could be easily bolted to the beams via tabs that slid into the channel. From this we built a rectangular frame made of these beams and connected at the corners with aluminum brackets designed to accept bolts that could screw into the tab inserts. An additional beam that roughly bisected the frame was attached to allow for anchoring the electrical box at the front of the boat. The beam in the rear of the boat was then thickened with plywood and another fiber glass beam to allow for the mounting of the twin motors.

3.2 Pontoons

The current pontoons are four feet long by six inches wide by eleven inches tall. They have just barely enough buoyancy to hold the boat up and there is a possibility that we may add more weight to the boat. So we have people from Elizabeth City State University building us more buoyant and stronger pontoons. These new pontoons will be five feet long and ten inches in diameter. The extra one foot of length will add stability to the boat which at the moment is a bit of a problem since the second the motors turn on the boat rocks backward, then when the motors turn off the boat tips forward. With an added foot on the pontoons this should lessen the amount the boat rocks forward or backward. The new pontoons are



hollow in comparison to the current pontoons, which have a foam core. This eliminates some weight, which will allow us to possibly add more weight later if needed. The fiberglass used in the new pontoons is also a better fiberglass then that used in the current pontoons, which will make them stronger then our current pontoons.

3.3 Frame Material

The old pontoons made use of blue square fiberglass beams. These beams had a T-slot cut the length of each side of the beam, which made mounting very easy and made it very adjustable. One problem with the fiberglass beams is that they are really heavy. So we found on McMasterCarr.com aluminum hollow square bars that are lighter than the current fiberglass bars on the boat. Each pontoon will have two mounting legs extending fourteen inches out the top of the pontoons and ten inches of leg extending into the pontoon for structural support. In total there will be eight feet of aluminum square hollow bars between the two pontoons. The weight saved per foot of aluminum bar is 0.7 pounds. So that's a total saving of 5.6 pounds on the pontoons. We expect to have these pontoons by May 1st. The decision to change frame materials wasn't expected to be made all other parts are completed and attached which couldn't happen until mid May. However this decision was reached recently with the release of the final competition rules at the end of April which induces a penalty on boats above 110 lbs.

4. Propulsion System

4.1 Motor Selection

Two Trawling motors with 30 lbs of thrust were selected for the project. The first motor came off last year's boat while the second was purchased for the project to be the same at the first. These motors were attached to the back of the boat by clamping on to a piece of plywood rather than the fiber glass beams its self as it provided a better hold. The speed of these motors could be easily controlled and varied which made them perfectly suited for our use. Later the motor from last year was removed and a second motor was purchased. The old motor's pole was to short and delay issues were noticed between the new and old motor.

4.2 Attaching the Motors to the frame

These motors attach easily to the frame via a mounting bracket attached to the motors but had to be modified to always be locked in square with the frame. This was quickly realized during our first water test, when the motors would cease to be parallel to one another and the boat frame while the boat was turning. The combined force of the water on the boat, in combination of the motor against the water, torqued the motors out of alignment. A simple solution to solve this involved drilling a hole into the pole and the motor bracket and inserting a cotter pin. The hole had to be drilled carefully so as to not drill into the wires.

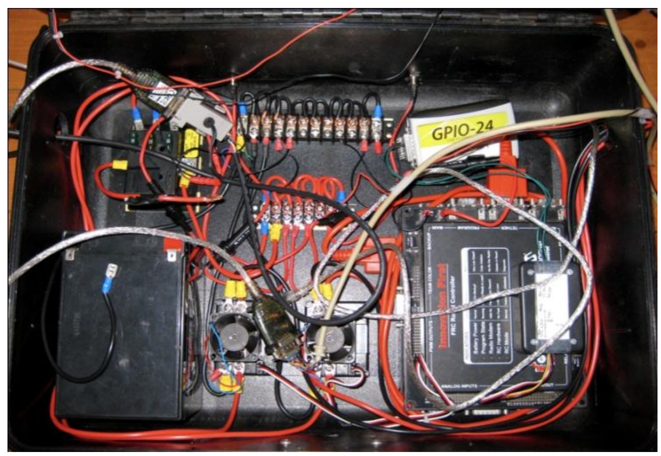
4.2 Blade Shields

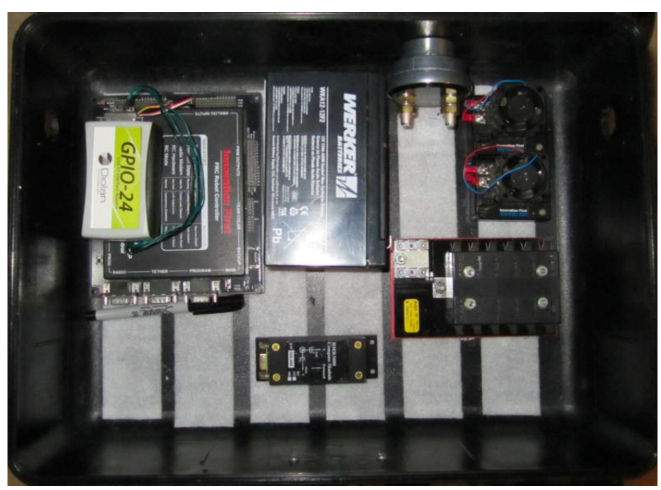
Shields are required for the competition to protect the propeller blades on our motors for safety reasons. To do this two members of our team from the Project Management 1 class drew up a design on Auto CAD. This design was of a circular guard similar to the one used during last year's competition, only the new ones are split along the middle of them at the top. This was done so that they can be made out of one piece and attach to the motor's pole. These guards have connector pieces at the top and bottom of them designed to attach them to the motor pole and the rudder fins on the motors. The guards have been ordered from, and are currently being constructed by Norva Plastics. At first, $500.00 was said to be the cost for the two guards, though Norva Plastics agreed to lower the price to $250.00 if they could put their logo on the sides of them, which we happily agreed to. Once arrived, they will be put onto the vehicle right away.

5. Electrical Box

5.1 Components

During our testing it was determined that a rewiring of the electrical box was needed. Inside this case are a FRC Robot Controller, a GPIO-24 USB-IO interface adapter, a 12Volt/12Ah WKA12-12F2 Werker Battery, a dual 35mm fan air-cooling system, a fuse box with 30amp fuses, and a laptop running the autonomous program. To abide by the competition regulations for safety, we have installed an external kill switch on the box in the case that we need to quickly turn off or disable the ASV. Changes that we are still working on included installing USB hubs and water-proofing the electrical box. The USB hubs will connect our





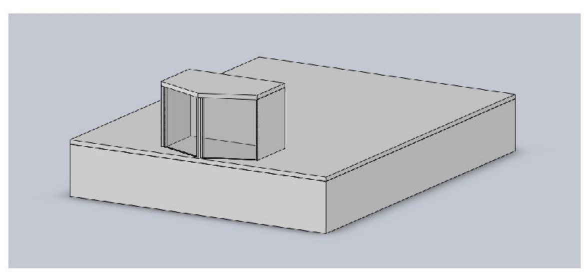
six external power-driven devices: the GPS, GPIO-24, Compass, two visual cameras, and one thermal camera.

5.2 Technical Issues Faced

One of the changes we made to the box is the replacement of our previous 10 amp fuses that had blown during our first test. Since we assessed that reducing the amperage load would not be feasible, we decided to upgrade our fuses' capacities instead. In addition to new fuses, we have also purchased a completely new fuse block; this allowed us to get rid of the distribution panels and clear up excessive wiring and used space. We have also replaced our 14 gage wires with more suitable 10 gage wires. At one point we were to use Kinect Cameras for the vision system but due to the camera not being able to detect the infrared signal in the sun light. The idea was dropped in favor of Logitech cameras that after testing were found to have good definition for our use and allow for the addition of as many cameras as we need.

6. Waterproofing Efforts

6.1 Waterproof Shield



The waterproofing is a critical part to the survival of our electronics. The waterproofing design had to be built to accommodate three functions. Firstly, it has to protect the electronics from water damage. Secondly, this shield still needs to allow for adequate airflow to cool all electronics in the electrical box. Lastly, the Rain shield will be rainproof camera mount. This rain shield will be placed on top of the existing lid of the electrical box. The original lid to the electrical box has holes in it that allow for air to flow into and out of the box. So this rain shield will act as a new lid that won't allow for water to get through. The cameras will be mounted in this protective rain shield. At the moment the cameras will be mounted directly to the electrical box as stated in the "quick camera mounts".

5.4 Waterproofing the Electrical Box

In our old boat design, we had an unsealed hole for the kill switch and two 1 inch holes and two .5 inch holes that we used to feed our wires from the electrical box to the motors and cameras. When we were tasked with waterproofing our electrical box, we assessed that the ports on the sides of the box will need to be sealed. In our new design, we plugged the side holes and sealed around them with silicone caulk, drilled a 2 inch hole on top, screwed in a male and female pvc connecting tube on both side of the lid of the box to feed the wires through, and caulked around the pvc tubes.

6. Cart

6.1 Introduction

According to the 2011 ASVC Mission rules, the autonomous surface vehicle must trailer mountable for the purpose of launching the ASV into the water. There will be a ramp provided so the ASV must also be secured to the trailer due the incline. Since the ASV will be launched by hand, not by automobile, we were present with a task of making a cart. The cart will not be judged on any specific criteria as long as there is a functioning trailer present.

6.2 Design

Keeping in mind of our team's overall concept of modular design and keeping things simple we set out designing our cart. There were a couple key design criteria that had to be taken into account before any construction was started. First, the main and overall idea was that one person needed to be able to move and launch the ASV without any help. Second, we wanted the cart to be able to fit in the back of the transport vehicle, with the ASV on top, without having to disassemble either device. Finally, we wanted the cart to also serve as a platform for dry tests of the ASV. This would allow for minor changes to be tested without actually having to launch the ASV in water. With these design aspects in mind we started brainstorming about the actual geometry of our cart.

Keeping with the modular design of this project, we decided to utilize the same blue channel beams that the ASV was constructed out of. We still had plenty of this material on hand so cost would not be an issue. The maximum overall dimensions that the ASV could be are 5ft by 3ft. So we built a rectangular frame that is slightly over 3ft wide and is 4ft long. A slight overhang of the boat of the cart is not an issue. This can be seen on many modern boat trailers. Two bunk, or boards, were bolt to the top of the frame so that ASV would have a flat surface to rest on. This would eliminate at point stresses to the pontoons. This would also allow for various pontoon designs to utilize the same cart design. There are a pair of straps for each pontoon that are secured at one end to the frame, that then stretch over the pontoon and hook into the other side of the cart. This is again a very simple, secure way to tie down varying pontoon designs. The wheels obtained for the ASV cart are 10in diameter solid hard rubber wheels. They have built in bearings and bushings. The wheels must be solid opposed to pneumatic so the cart would sink when launching the ASV. The wheels were then through bolted on either side of the rectangular frame using 5/8in grade five bolts. The holes for the bolts were drilled one-third the total length of the cart from the back in each side rail of the cart. This gave the proper leverage needed to support the cart but still lift the front end.

The front end is supported by two vertical pegs when at rest. A simple handle was attached to lift the front end when the cart needs to be moved. After looking at the finished product all design criteria were either met or exceeded by this simple cart design.

7. Electronics and Components

7.1 Quick Camera Mounts

The boats cameras will be mounted inside a waterproof shield that will be mounted on the electrical box. At the moment the waterproofing shield is not done so we need a quick way of attaching the cameras so we can continue to do testing. We will be using two cameras on the boat and the size of the base plate for each is one inch by one inch. We will take a piece of wood two inches by eight inches to fix the cameras to. This wood plate will have Velcro on the side that will mount to the electrical box. The reason for Velcro is because we want to be able to remove the camera plate easily so we can make adjustments to the cameras in a lab without having to take the entire electrical box into the lab. The cameras will be mounted to the wood plate by drilling two holes in the cameras base plate and into the wood piece. This allows us to firmly fix the cameras to the wood plate so they don’t move, but gives us a method for removing the cameras later for when we transfer them to the proper plate that will be used with the waterproof shield.

7.2 Computer Defragmenting

Currently, all of the vehicle's operations are controlled using the coding written on the computer located within the electronics box. Since the vehicle cannot function without this coding, the computer's battery power is important. To help make sure that the computer will not lose power during the competition, one of the group members will be removing excess programs running on the computer in the background. This should not only improve the battery life of the computer, but improve the speed of it as well. Some of the other precautions being taken include configuring the power options of the computer such as sleep mode, screen saver, and screen brightness settings. Properly configured, the battery life of the computer should improve. The group member working on cleaning the computer expects to finish doing so by early May.

7.3 Sonar Range Finder

One form of feedback to the boat will be the Range finder, which uses sonar technology. The range finder basically uses the knowledge of the speed of sound to determine how far away an object is. The range finder has two speakers on the front plate. One speaker will produce a sound that will propagate outward from the plate until it hits the nearest object. When the sound wave hits an object it will bounce back to the plate and be received by the second speaker. The time it takes for the sound to travel from the first speaker out to an object and back to the second speaker can tell us how far away an object is from the two speakers. To determine the distance we first must determine the speed of sound in our environment. The speed of sound is determined from the equation sqrt(gamma*R*T). Since the temperature varies we must recalculate the speed of sound when testing conditions change. We calibrate this by placing an object a specific distance away from the speakers and record the time it takes for the sound to reflect back to the speakers. We could also use this to determine the temperature if we wanted to. After obtaining the correct speed of sound we can now use this to determine the distance to objects at unknown distance away from the speakers. The current range finder is accurate out to ten feet.

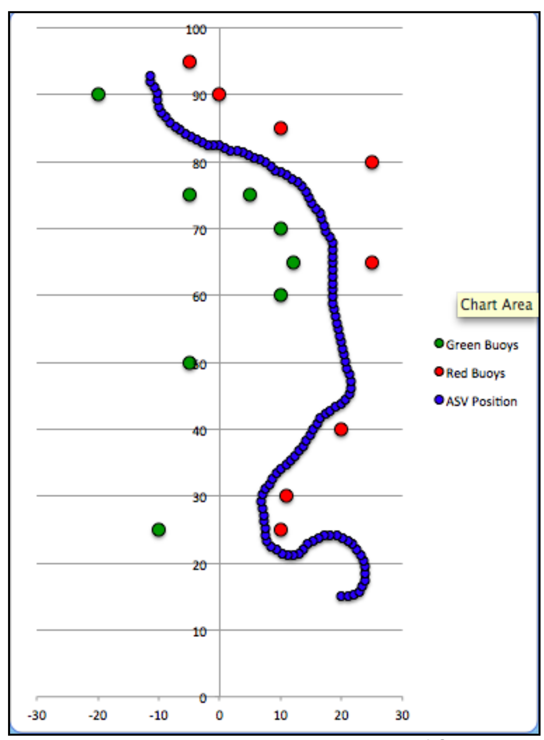
7.4 **Water Cannons**

One of the tasks that the vehicle will be required to complete, will be to spray water inside of a rectangular hole that is 2-6 inches tall and 6-12 inches wide. The hole will have a red border around it and be located within a 2-4 feet long and 1-3 feet tall boat prop. In order to complete this task, the vehicle must first find the desired target by distinguishing it from other objects on the course. To do this, the red rectangular border will need to be noticed by our vehicle's two cameras using the c++ vision coding. Once recognized by the program, it will allow power to be provided to one or two pumps, and they will then spray the water. The bilge pumps removed from the vehicle used during last year's competition will be reused for this year. The number of pumps that will be used is still being decided by the two group members working on this task. These pumps will be located below the frame of the vehicle within the water. They will be attached to a blue fiberglass beam that will be perpendicular to the frame, and connected to it. From the pumps, clear rubber tubing with a nozzle at the ends will go up to the frame of the boat above the water, and connect to it. The exact locations and how the hoses and pump will be connected, as well as the coding for this task, are all still being worked out. The water cannons should be working before the competition date, and are expected to be tested before June.

8. Logic

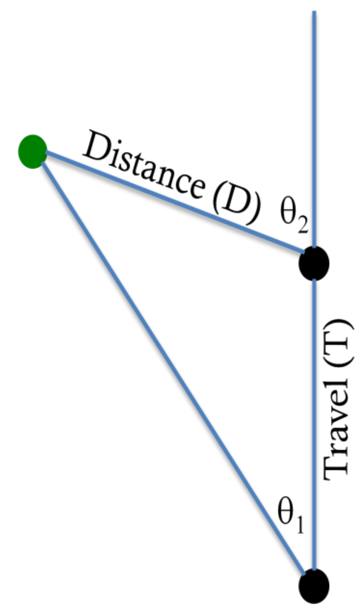
8.1 Vision and Logic Integration

The Camera vision software uses C++ libraries written by OpenCV. These functions give us an easy method of taking in images from cameras mounted on the boat. The first thing the code does is read in an image from each camera. The two pictures are then combined to make one widescreen picture to process. This picture is converted from RGB, red-green-blue, format to HSV, hue-saturation-value format. HSV is an easier signal to work with. The picture is then converted into four pictures Red, Green, Blue and Yellow. The pictures are then put

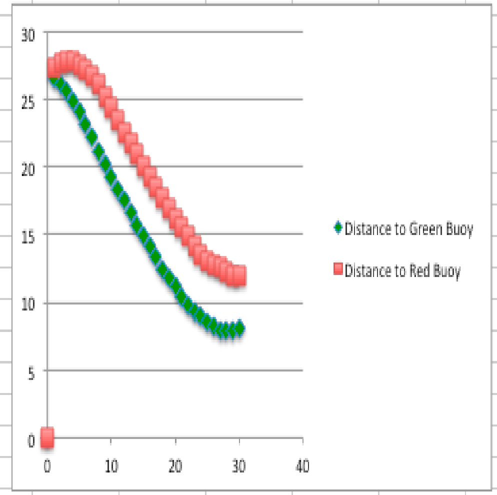


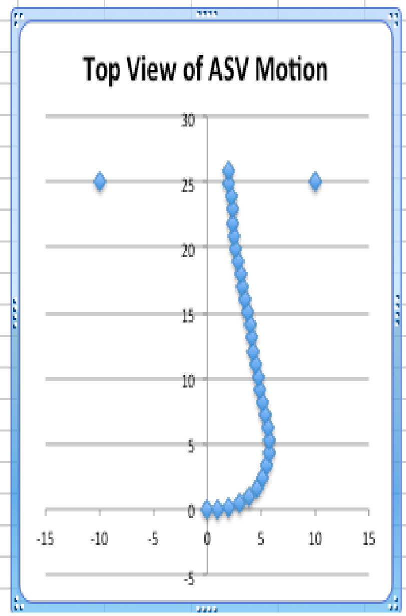
back together and go through a Hough Transform. This does a search through the picture for circles. After this process we have now located the centers of all the buoys in the four colors we are searching for. Next, we record the pixel row and the pixel column for the centers of each buoy in the picture frame.

The logic now takes control. The first thing the logic does is sort out the buoys, because we might get more than one buoy of the same color. The logic determines the closest buoys from the fact that the closest buoy will appear lowest in the picture frame. After this step we will only have a max of four buoys, one of each color. Next the buoy information gets sorted into one of sixteen scenarios. An example of the first scenario is if you don't detect a red green blue and yellow buoy, the last scenario is if you can detect all four buoys in the same picture frame. Each scenario will make various decisions based on the angles the buoys are from straight ahead. When the logic has determined how the boat should move it sets the duty-cycle for the motors to the proper level to get a specific rotation or movement. This is updated on the next loop of the code. This continues until the boat has reached the end of the navigation channel, which is marked by a blue buoy.



	-10	25						
	Red Buoy Position							
	10	25	Angle To Red Buoy	Angle To Green Buoy	Distance to Green Buoy	Distance to Red Buoy	New Angle Change	Total Angle Change
Iteration	ASV (X)	ASV (Y)						
0	0	0	-68.1986	-111.801	0	0	0	0
1	1	-4.37E-08	-64.2011	-107.749	26.5706	27.313	-6	-6
2	1.99452	0.104528	-54.1741	-97.7245	26.151	27.6343	-6	-12
3	2.94558	0.413545	-43.9906	-87.7683	25.5785	27.7863	-6	-12
4	3.8116	0.913545	-33.591	-77.8307	24.8687	27.7655	-6	-12
5	4.55475	1.58268	-22.9096	-67.8625	24.0421	27.5719	-6	-12
6	5.14253	2.39169	-11.8742	-57.8133	23.1243	27.2109	-6	-12
7	5.54927	3.30524	-0.406502	-47.6303	22.1466	26.6915	-6	-12
8	5.75718	4.28339	11.5743	-37.2568	21.1477	26.0283	-6	-12
9	5.75718	5.28339	21.1443	-29.6313	20.168	25.2395	-3	-9
10	5.60075	6.27107	28.2186	-24.7935	19.2387	24.3754	-3	-6
11	5.34193	7.237	29.6941	-25.8172	18.3636	23.4712	3	0
12	5.08311	8.20293	25.316	-32.9226	17.5019	22.5752	3	6
13	4.92667	9.19061	26.7917	-34.355	16.6035	21.7427	-3	0
14	4.77024	10.1783	34.4351	-29.9004	15.7173	20.9247	-3	-6
15	4.51142	11.1442	36.6096	-31.324	14.9033	20.064	3	0
16	4.2526	12.1102	33.0314	-38.8743	14.1131	19.2168	3	6
17	4.09617	13.0978	35.3828	-40.8238	13.286	18.4489	-3	0
18	3.93973	14.0855	44.0413	-36.9399	12.4841	17.7043	-3	-6
19	3.68091	15.0515	47.4228	-38.9759	11.7858	16.9157	3	0
20	3.42209	16.0174	45.215	-47.2079	11.1336	16.1506	3	6
21	3.26566	17.0051	49.1083	-49.9235	10.4533	15.4886	-3	0
22	3.10923	17.9928	59.5199	-46.8743	9.82772	14.8645	-3	-6
23	2.85041	18.9587	64.8026	-49.8205	9.36026	14.1997	3	0
24	2.59159	19.9246	64.5855	-59.0467	8.98021	13.576	3	6
25	2.43515	20.9123	64.6152	-68.8032	8.59862	13.0898	3	6
26	2.38282	21.9109	70.9255	-72.9926	8.21971	12.7623	-3	0
27	2.33048	22.9096	83.7535	-71.3779	7.94931	12.5064	-3	-6
28	2.17405	23.8972	90.9793	-75.8241	7.90326	12.2239	3	0
29	2.01761	24.8849	92.1741	-86.4514	7.98322	12.0181	3	6
30	1.96528	25.8836	93.2755	-97.2233	8.08316	11.9978	3	6





9. Testing Considerations

9.1 Test Course

To better prepare ourselves for the competition, a practice course will be constructed. The course will contain all of the main tasks and obstacles from the competition. This includes: red buoys, blue buoys, yellow buoys, waterfall test, and a hot target. There are several possible ways to go about doing this. For the buoys, the actual ones being used during the competition are given within the preliminary rules, so they could be purchased. However, spending money on buoys that could be easily made from weighted down balloons or painted cardboard cut-outs is not the best use of funding. For that reason, the buoys will most likely be constructed by one of the before mentioned ways. As for the waterfall test, that could be simulated by pouring water over the top of the vehicle. Nothing would be required except for buckets or hoses, which can be easily obtained. And the hot target test would only require producing an area with a high temperature. One of the group members not enrolled in ME435 is currently constructing a test course to be used, and plans on having it completed early May.

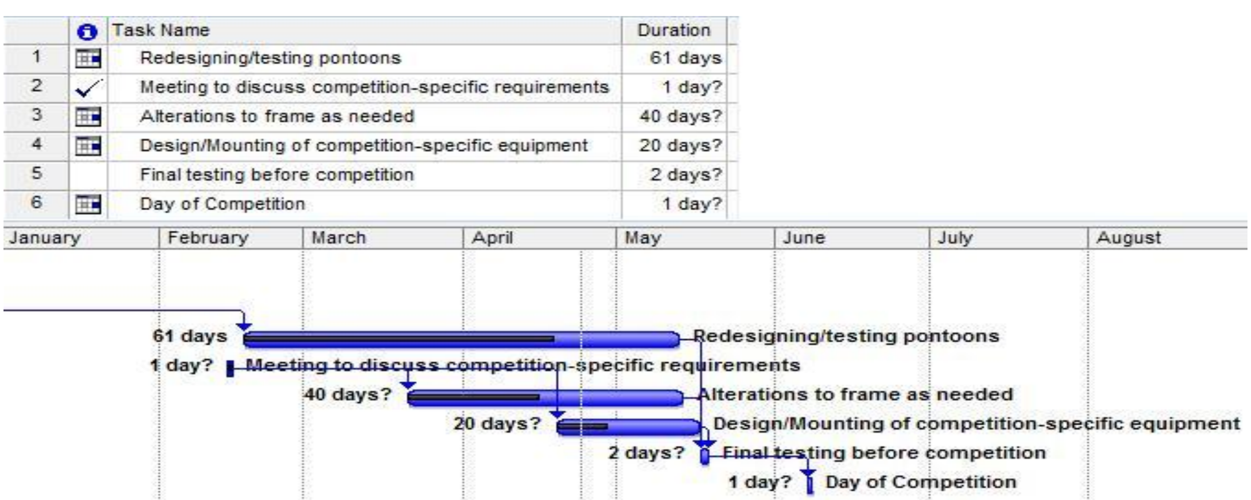
10. Team Organization

10.1 Budget

At the beginning of the spring 2011 semester, we were informed that we had a starting budget of $3000. This budget seemed very generous, especially since the two motors that we had purchased during the previous semester were covered with departmental funds. As of April 24, we have spent just under a thousand dollars and are expecting to spend a couple hundred dollars on the competition's registration fees, so we are expecting to have $1860 left in our budget after the competition. Our big items were the Kinect cameras ($300) which ultimately did not work out for us, the potential frame material upgrade($200) if we need to reduce any more weight, a third motor ($100) to replace one of our first two motors, and motor shield ($250), which are required for the competition.

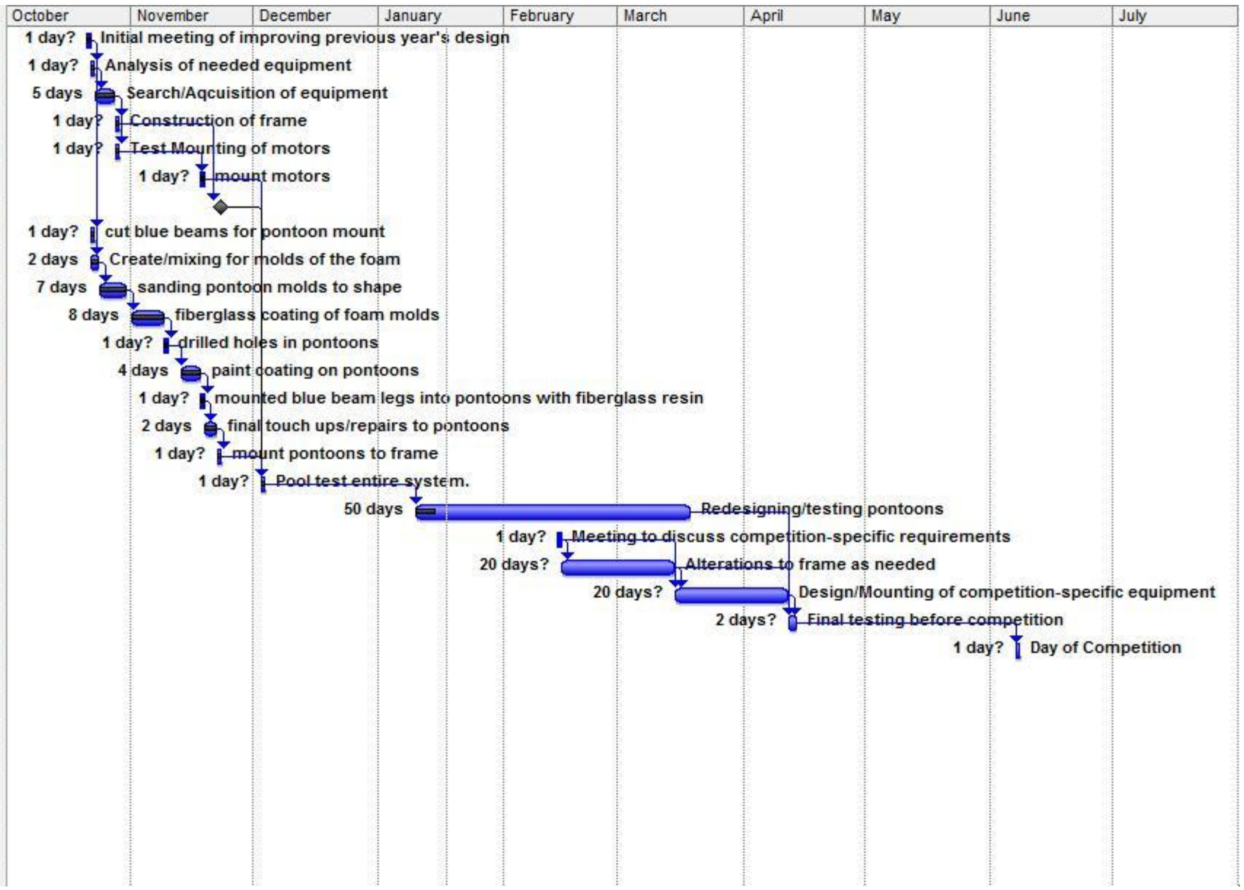
10.2 **Schedule/ Gantt Chart**

According to our proposed Gantt Chart, we planned to have our new pontoons from Elizabeth City University installed and tested by mid March, upgrade our frame material by mid March, design and mount the task-specific devices by mid April, and be done testing everything by mid April to beginning of May. Realistically, we left a month of free time in between the competition and our last proposed event for the case that any of these tasks ran over time. This extra month became necessary because we are still waiting on our new pontoons, we have just started designing one of the task-specific devices, and we decided to not upgrade the frame's material until we install all of the devices and test the ASV. On top of the mechanical components of the ASV, we have tested the code from the electrical engineering team and have assessed that their code is too flawed to work, so we have had to scratch their code and build our own program. In addition to the program coding, we are still working on our vision detection code, which is progressing rather well. Though we are behind on the schedule, we do not foresee any problem with finishing our tasks and water-testing before the competition.



Gantt Chart

	Task Name	Duration
1	Initial meeting of improving previous year's design	1 day?
2	Analysis of needed equipment	1 day?
3	Search/Aqcuisition of equipment	5 days
4	Construction of frame	1 day?
5	Test Mounting of motors	1 day?
6	mount motors	1 day?
7	mount cameras/electrical box to frame	0 days
8	cut blue beams for pontoon mount	1 day?
9	Create/mixing for molds of the foam	2 days
10	sanding pontoon molds to shape	7 days
11	fiberglass coating of foam molds	8 days
12	drilled holes in pontoons	1 day?
13	paint coating on pontoons	4 days
14	mounted blue beam legs into pontoons with fiberglass	1 day?
15	final touch ups/repairs to pontoons	2 days
16	mount pontoons to frame	1 day?
17	Pool test entire system.	1 day?
18	Redesigning/testing pontoons	50 days
19	Meeting to discuss competition-specific requirements	1 day?
20	Alterations to frame as needed	20 days?
21	Design/Mounting of competition-specific equipment	20 days?
22	Final testing before competition	2 days?
23	Day of Competition	1 day?



Conclusion

The Project has fallen behind schedule by about a week due in part to the mechanical team having to take on the duties originally assigned to the Electrical team. This has caused us to have to take on the duties of working the logic, vision system, sonar detectors, and wiring of the electrical box. We managed to not get terribly far behind due to aggressive recruiting on the part of our advisor and team leader. As a result it will still be possible to produce a working boat come competition time. However, various subtasks, such as the Amphibious landing, were not feasible to complete so they weren't perused. Instead we began the project with clear goals to achieve the main tasks and the sub tasks that require little additional effort because they parallel existing tasks that must be completed for a functioning boat, such as the waterproofing efforts. Hopefully next year's team will benefit from these lessons and our modular design so more testing and improvement on the foundations of our design can be made.

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