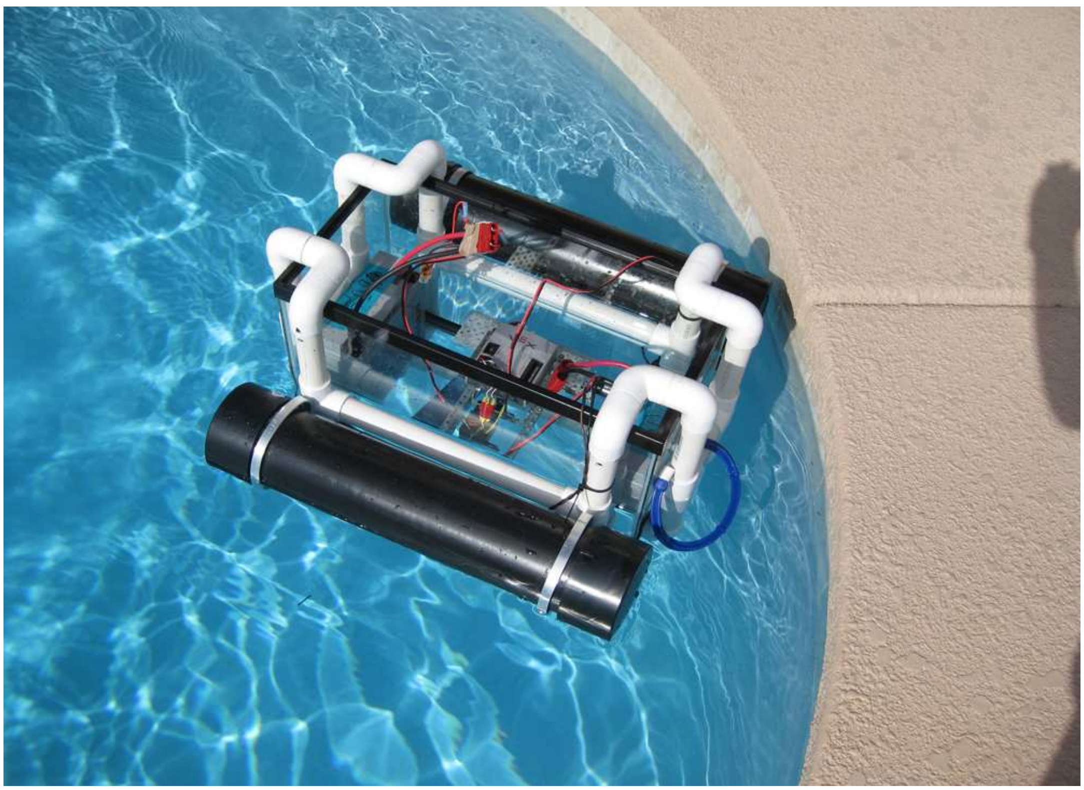
Nifty Engineering Robotics Design Squad

Buena High School
5225 Buena School Blvd.
Sierra Vista, AZ 85635
National Underwater Robotics Challenge 2009

Project [X]



Team Members:

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Mentors:

Steven Forbes (Alumnus), Mr. Forbes (Engineer), and Mrs. Schwarz (Teacher).

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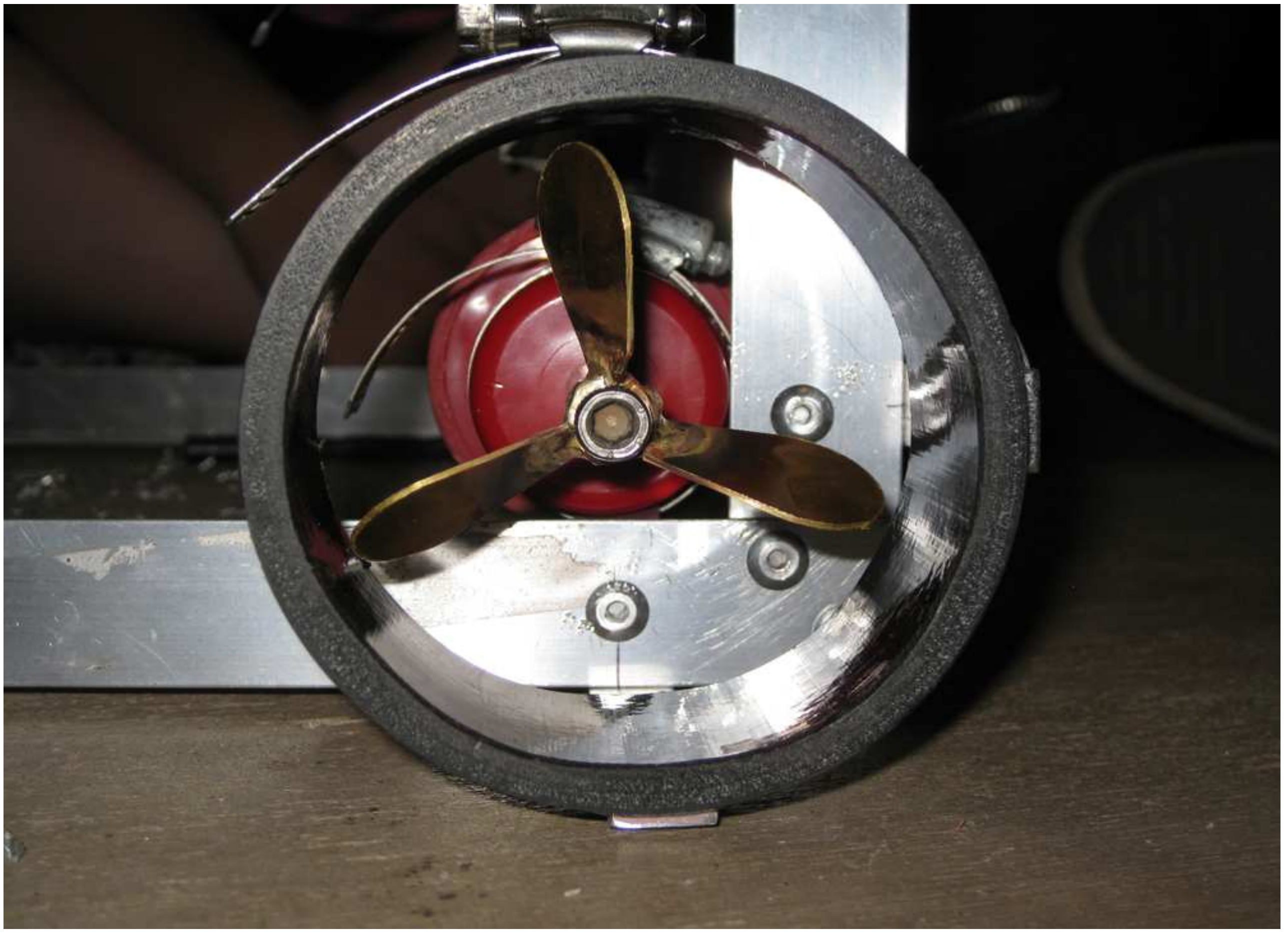


Abstract

Having completed four years of the FIRST Robotics Competition and two strong showings in previous National Underwater Robotics Challenges, our team was prepared to meet this year's challenge of “Fire Under the Ice”. Members with previous experience were able to guide the new members with various aspects of design. Every teammate contributed to the overall effort and provided his or her own unique point of view.

Our simplistic approach to this year's challenge was a product of time constraints and the availability of materials. We prioritized the mission tasks using a proven point matrix system. Once

we determined our main goals for the mission, the team established design criteria for the most effective robot system to accomplish these goals. The consensus produced a desire for the following attributes: visibility, versatility, precision, and power.

This year's design features two independent remote units with off-board electronics. One unit serves as an overhead view and light source while the other performs the mission's critical tasks. Similar to last year, the submersible unit has a simple hooked manipulator. However, we are using more powerful motors and propellers based off those used on radio-controlled racing boats. These aspects provide more precision and power, two of our main objectives.

The elements employed in these efficient designs showcase innovation and originality. The team's creativity manifested itself to shape our final products and exhibit the benefits of science and technology in today's world.

Mission Prioritizing

Engineering is the process of designing, testing, and building a solution to a problem at hand. The team first prioritized the objectives of the mission "Fire Under the Ice" based on a +1, 0, and -1 system so that the design of the robot was in mind. This system also helped eliminate certain designs. The objectives were scored on simplicity, point value, risk, time, feasibility, and the overall group opinion of the objective.

	Simplicity	Point Value	Risk	Time	Feasibility	Group Opinion	Total	Order
Free Anchor	+1	-1	+1	+1	+1	+1	+4	3
Emergency Descent Device	+1	-1	+1	+1	+1	+1	+4	4
Work Lights	+1	0	+1	+1	+1	+1	+5	1
Mooring Station	-1	0	0	0	0	0	-1	9
Scientific Package	-1	+1	0	-1	+1	+1	+1	6
Glacial Core Samples	0	+1	-1	0	0	+1	+1	8
Temperature Vent	+1	0	0	+1	+1	+1	+4	2
Sound Recorder	0	+1	+1	0	-1	0	+1	7
Generic Core Samples and Bacteria	0	+1	0	-1	+1	+1	+2	5

The design of the robot was simple to determine after prioritizing and analyzing the objectives.

Design Rationale

Our design approach this year first involved looking back at our previous iterations and finding the problems in them. We also had to factor in our low budget of $1000, which meant we had to aim for a cost effective solution to the mission scenario. This involved using parts from previously built robots to prevent excessive spending. Cameras, wires, speed controllers, and some other expensive items were recycled in an attempt to quickly compensate for our lack of funds and time. In this way, our designs swiftly evolved from design sketches to their tangible, living forms. Several issues with our last two competition robots included high complexity and poor fabrication. Our TRIDENT system failed due to low mass and lack of lighting, and Tacky Sponge, our first entry, had no external viewpoints and an extremely thick tether.

Using this information, we decided that an extra vantage point would be beneficial but creating two waterproof robots would be too costly and time consuming for that purpose. A few brainstorming sessions yielded a system utilizing an average sized ROV similar to Tacky Sponge and an overhead boat to assist with lighting and viewing capabilities. The boat required little waterproofing and could thus be made wireless. The ROV could be constructed easily with few tools while still allowing us to accomplish every task. Off-board electronics eliminate waterproofing complexity and allow for fast prototyping.

By looking back on our misconceptions, we were able to create simple but effective solutions to the tasks presented to us.

Boat

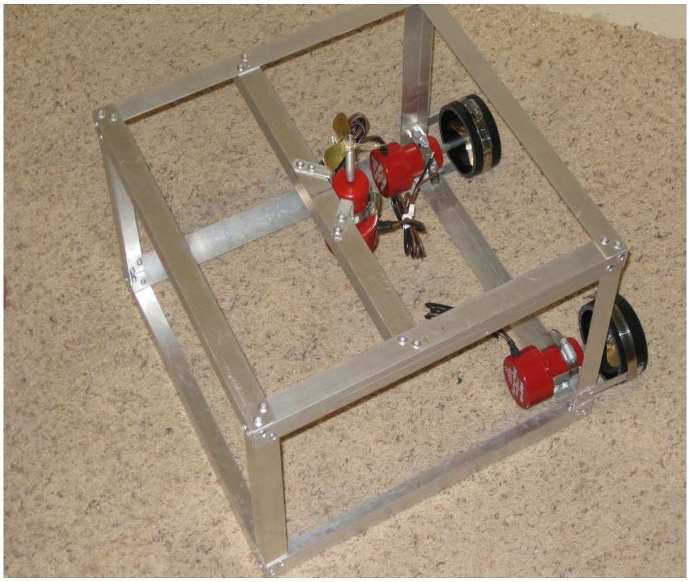
The purpose of the boat, dubbed USS Awesome, is to assist the ROV in navigation by providing an additional point of view and several 50-watt halogen lights for illumination. It was designed and manufactured with readily available parts, including PVC, ABS, and a fish tank.

The design revolves around a flat surface that provides the camera and lights with a nice medium for viewing the underwater environment. An obvious waterproof solution was a standard fish tank, but the problems of connecting motors and keeping it stable arose. Using the CAD software Inventor, we modeled an outer shell of PVC before beginning fabrication. 500 GPH bilge pumps are attached using hose-clamps, and 4” ABS pontoons are attached with aluminum strap for stability. An on-hand vex microcontroller allows for wireless control and proportional control of the bilge pumps. We used vex hardware to create a gimbal to mount a board camera and several halogen lights. A thin CAT-3 cable connects the camera to the surface controls for video feedback while also acting as a tether. The electronics are a modified version based on last year's TRIDENT robots, including two vex 7.2v batteries wired in series, two BaneBots 3-amp continuous speed controllers, and camera power. A separate system for the lights is run on a 12v motorcycle battery.

ROV

The ROV's purpose is to provided the human operators with a camera point of view underwater and to allow the the operators to manipulate underwater objects.

Our ROV, dubbed Starman, is a straightforward approach to this year's challenge, “Fire Under the Ice.” It features three Rule 1100GPH bilge pump motors: two for horizontal motion and one for vertical movement. Homemade three-blade propellers, fashioned after radio-controlled racing boats, were crafted from brass nuts and sheet metal. The ROV is also outfitted with a camera, temperature gauge, hook for manipulating objects, lights, and a microphone. Starman receives his power from shore side batteries. During one of the team's brainstorming sessions, the idea of off-board electronics was suggested, and we soon realized it greatly simplified the construction of the system as a whole. The ROV shell consists of a riveted rectangular aluminum frame, making the remaining components a cinch to attach while leaving them easily accessible. All three motors have cylindrical ABS ducts to prevent entanglement that might occur and to direct the propellers' thrust.



Surface Control System

The surface control system includes all the components of control and all the forms of user interface the are based on the ground. This includes the monitors for viewing camera points, the input controls, and the ground based electronics.

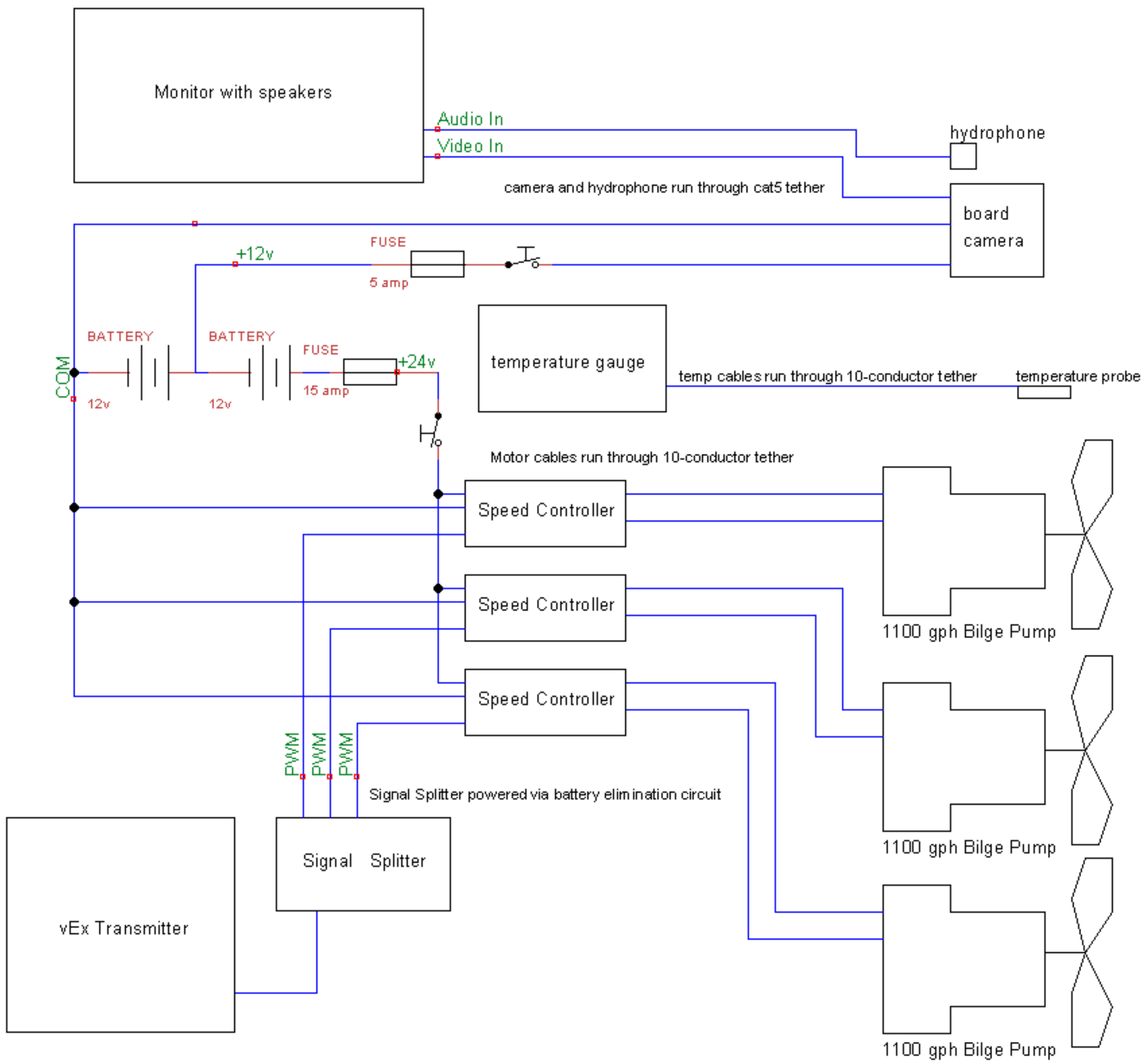
Our system uses two 12 volt 18 amp-hour motorcycle batteries, which are the standard power source for FRC robots, wired in series for a 24 volt nominal system. Two monitors display the camera points, one for the boat's camera and one for the ROV's camera. Two Vex transmitters serve as the user input devices.

All the electronics for both the boat and ROV are off board. This simplifies the waterproofing and gives us more time for prototyping and redesign. It also allows the satellite units to weigh less, which makes moving them easier.

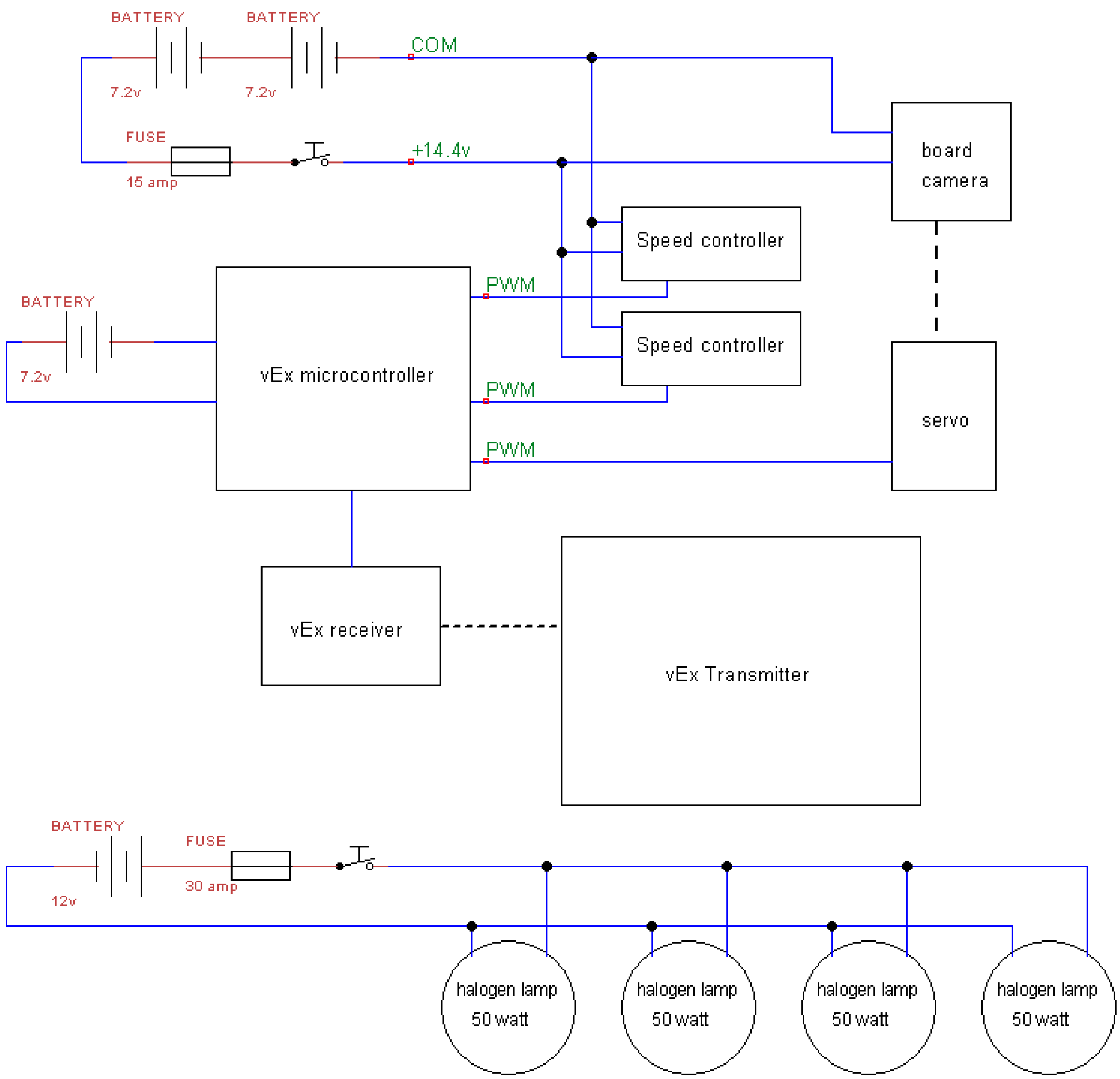
A temperature probe is attached to the tether and is read by a Simpson gauge on the surface.

Electronics Diagrams

ROV electronics schematic



Boat electrical schematic



Lessons Learned

During this year's NURC build, our team learned valuable lessons about many aspects of engineering. The experiences we had in the past few weeks have taught us the importance of careful time management and planning, prioritizing design attributes for the sake of simplicity and cost-effectiveness, and preliminary prototype testing.

Our robotics club was preoccupied with other events and activities for the first few months of the year, which caused us to neglect work on our NURC entry until a month before the competition. This time restriction has caused us to limit our design aspirations as well as testing time, which we believe has severely impacted the performance of our solution to the mission requirements. These limitations have also served as a strong teacher, motivating us to learn to use our time wisely as well as start planning for next year's challenge much earlier to allow for flexibility in our schedule.

The time and cost constraints we had with this project led us to determine what sections of the challenge we felt were most conducive to success while being feasible in our situation. This has taught us the value of systematically evaluating every task and comparing them on the basis necessary for selecting the mission segments with the most benefit. We learned how to maximize our solutions performance for resources that we had not considered restrictions in past projects.

Finally, we learned the effectiveness of testing preliminary ideas so that we could best plan for the most effective means to accomplish our goals.

Expenses

Item:	Cost:
Fish Tank	$16
PVC pipe and fittings	$20
ABS pipe and end caps	$15
Aluminum strap, angle, rivets	$30
Banebots 5-amp speed controllers	$135
Banebots 3-amp speed controllers	$60
Vex signal splitter	$20
Three Rule 1100gph bilge pumps	$120
Two Mayfair 500gph bilge pumps	$30
Vex microcontroller	$150
Tether cables	$100
Misc. electronics	$60
Cameras	$80
Propeller material	$10
Hose Clamps	$10
TOTAL	**$856**

Acknowledgments

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