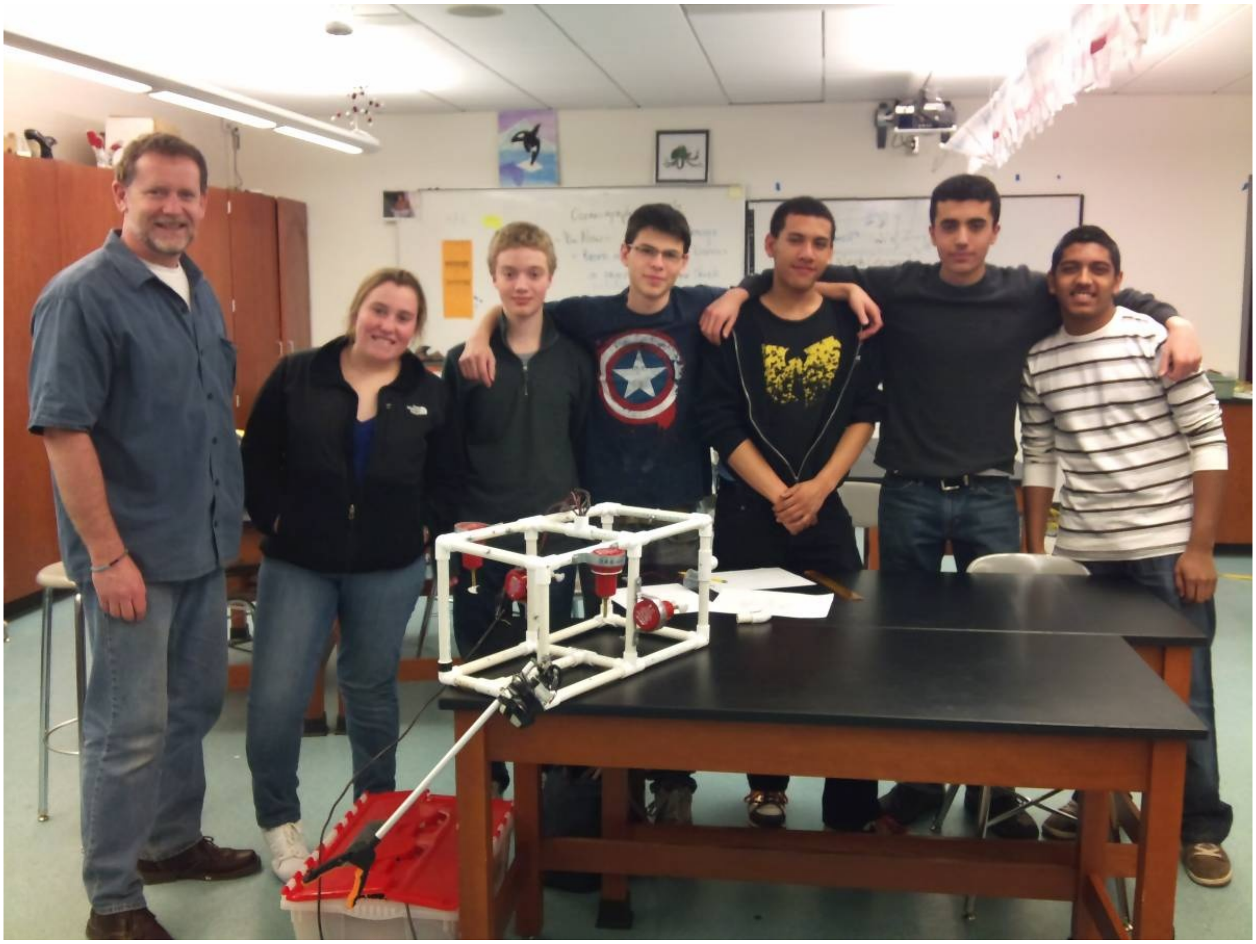

Cambridge Rindge and Latin Underwater Robotics Team

Natatory Technologies (N-Tech)

Cambridge, Massachusetts

Paul McGuiness (mentor)

Team Members

CEO: Alexander Chiclana 11′ (returning)

CFO: Imtiyaz Hossain 13′(returning)

Systems Engineer and Pilot: Simran Dhillon 12′ (returning)

Government and Regulatory Affairs: Eric Macomber 11′ (returning)

Design Integration: Amy Campbell 12’ (returning)

Research and Development: Imityaz Hossain 13’ and Jonah Saltzman 13’ (returning)

Consultants: Alexander Sender 12’ (new), Arthur Moore 12’(returning) and Sydney Agger 12’ (new),

Team History

The CRLS Underwater robotics team has participated in the MATE ROV competition for ten years. The team has participated in both regional and international competition. The team won the national title in 2003 and 2004. The team has also qualified for nationals/internationals in 2002, 2003, 2004 and 2009.

ROV Spec Sheet

ROV Homar

(*Homarus americanus*)

Value: $299

Weight: 8.3 kilograms

Primary Materials: PVC

Safety Features: “Danger” stickers on all motors, wired mesh to cover motor blades and “dangers” stickers near all electrical components

Special Features: Made from 100% recyclable materials and reusable materials.

Abstract

The April 2010 explosion of the Deepwater Horizon oil drilling platform was an ecological disaster on a scale so massive that its effects, from the immediate destruction to human life and property as well as that of nearby aquatic organisms, to effects on the ecosystem of the earth as a whole, are still being assessed. Although over a year has passed since the spill, it isn't too late to attempt to slow or lessen the harmful impact of deep-sea oil exploration on ocean life, whether by dealing with the ongoing effects of the Horizon disaster or by designing methods to prevent catastrophes like it in the future.

Our company's goal is to accomplish both of these tasks. As a group of entrepreneurs with an understanding of both business and engineering, we are positioned to anticipate the problems of the deep-sea oil drilling industry and adapt to any subsequent challenges as they develop. Our ROV is designed with the demands of the market in mind, and is able to perform both diagnostic tasks, such as the collection of water and biological samples, as well as repair, as shown by its capacity to cap oil wells and cut riser pipe in the event of an emergency. Throughout the process, accomplishing practical, complex goals through simple and efficient design was our first priority.

Background Information: The Deepwater Horizon Oil Spill

The *Deepwater Horizon* oil was an oil spill in the Gulf of Mexico which flowed for three months in 2010. The impact of the spill continues even after the well has been capped. It is the largest accidental marine oil spill in the history of the petroleum industry. The spill stemmed from a sea-floor oil gusher that resulted from the April 20, 2010, explosion of *Deepwater Horizon*, which drilled on the BP-operated Macondo Prospect. The explosion killed 11 men working on the platform and injured 17 others. On July 15, 2010, the leak was stopped by capping the gushing wellhead after it had released about 5 million barrels of crude oil. Around 53,000 barrels per day escaped from the well before it was capped. On September 19, 2010, the relief well process was successfully completed, and the federal government declared the well "effectively dead".

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Budget/Expenses: ROV

Purchased 2011		Formerly Purchased/Donated	
Item	**Cost**	**Item**	**Cost/Value**
-2 40 rpm motors	**$4 each**	-PVC Pipes	**$10**
-2 7" LCD screens	**$45 each**	-5 Thrusters	**$30 each** **$180 total**
-1 Pikstik Aluminum Reacher	**$19**	-2 Black and White Video Cameras	**$99 Each** **$198 total**
-1 Plastic Toolbox	**$10**	Metal Netting	**$5**
-**1** Genesis 200 Depth Gauge	**$50**	Tether Wrap	**$10**
		Kickboard	**$7**
TOTAL COST: $177		**RECYCLED/DONATED VALUE: $122**	**TOTAL ROV VALUE: $299**

Budget/Expenses:Travel

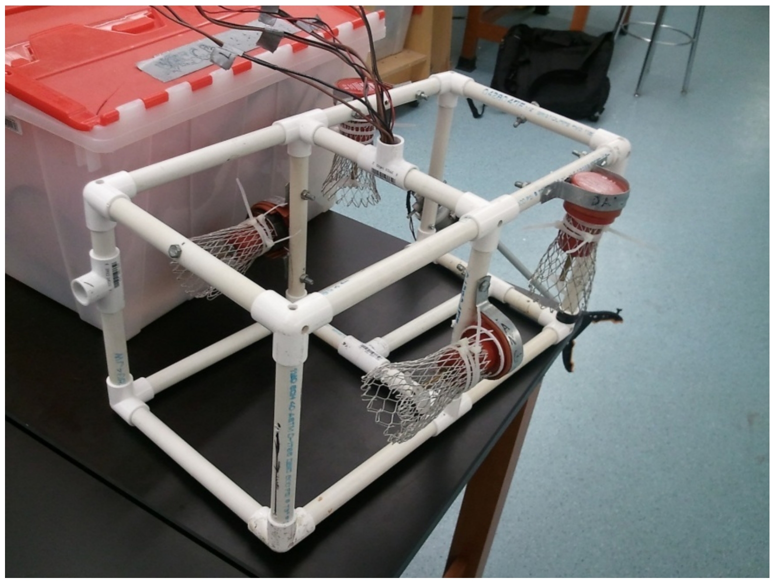
- Travel to/housing in Houston: Approximately $650 for each member; **9 people including chaperones:$5850**

- Promotional materials/Shipping: Approximately $500

Total:**$6350**

Design Rationale

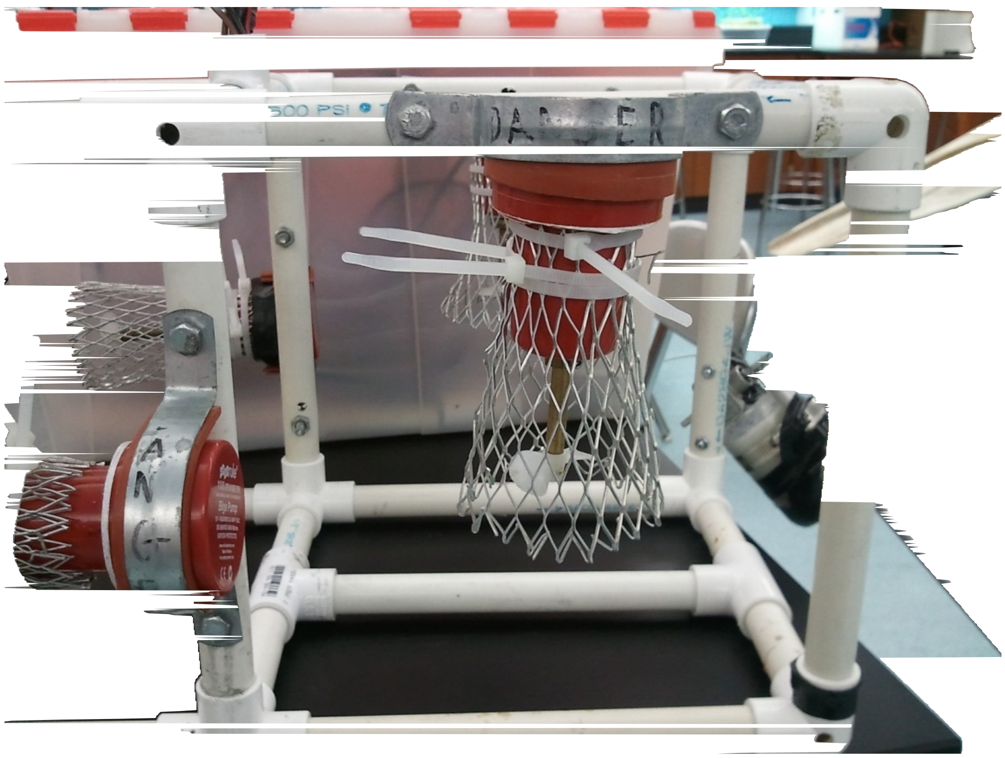
Frame: Given our need to attach several payloads and tools for the mission tasks, the frame was designed with simplicity in mind. We used PVC to make a rectangular frame with T-bars crossing the center on the top and bottom. The simple shape gave us the flexibility to adjust systems as we needed to, and the PVC was crucial in containing the wires leading from the systems to the tether.



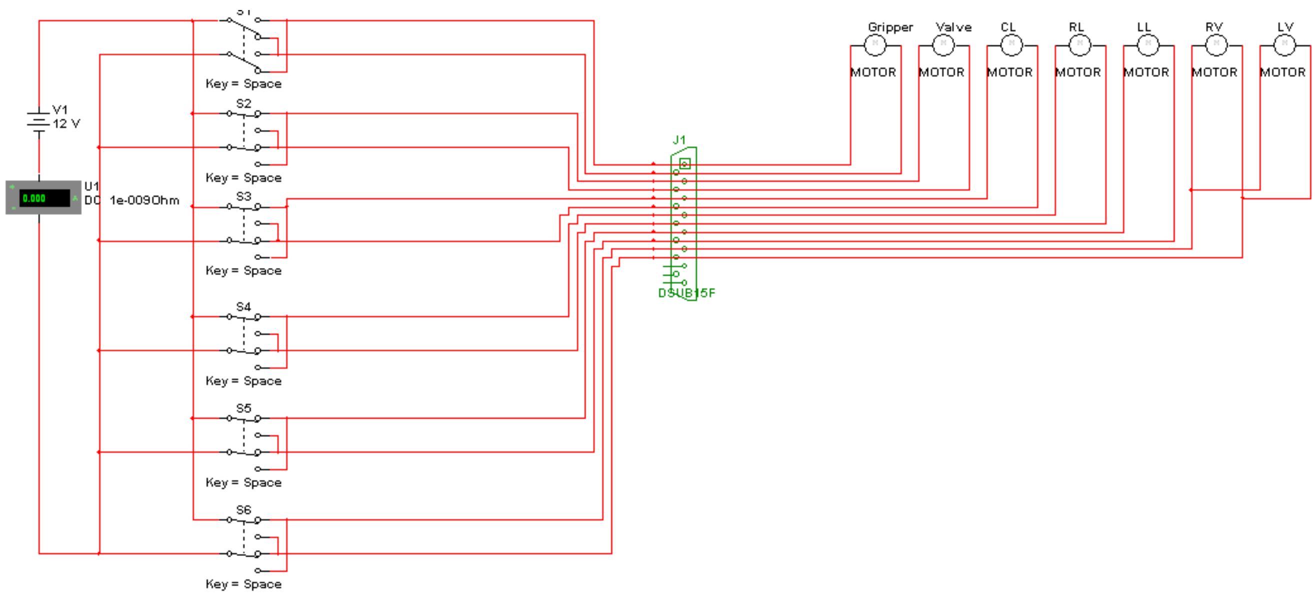
Buoyancy: We elected to keep the ROV neutrally buoyant, as many of the tasks of the mission required delicate and precise maneuvering that positive or negative buoyancy might interfere with. To offset the weight of the ROV, we used positively buoyant polyurethane and store-bought kickboards, and distributed it across the frame evenly to ensure neutral buoyancy.

Propulsion: Our propellers are four 1100 GPH bilge pumps and one 700

GPH bilge pump. Two 1100 pumps are used for forward and backward movement and the remaining two are used for up/down movement The single 700 pump is used to aid in reverse movement, which plays an especially important role in completing the valve wheel mission.



Control Box: The control box’s casing is made from a normal hardware store tool box. The plastic material allowed us to mount switches easily without making the controls difficult to hold or use. We chose to use an analog electrical system rather than a digital one, as the analog system was capable of accomplishing all of the tasks, but were much easier to design, troubleshoot, and maintain without compromising the functionality of the ROV.



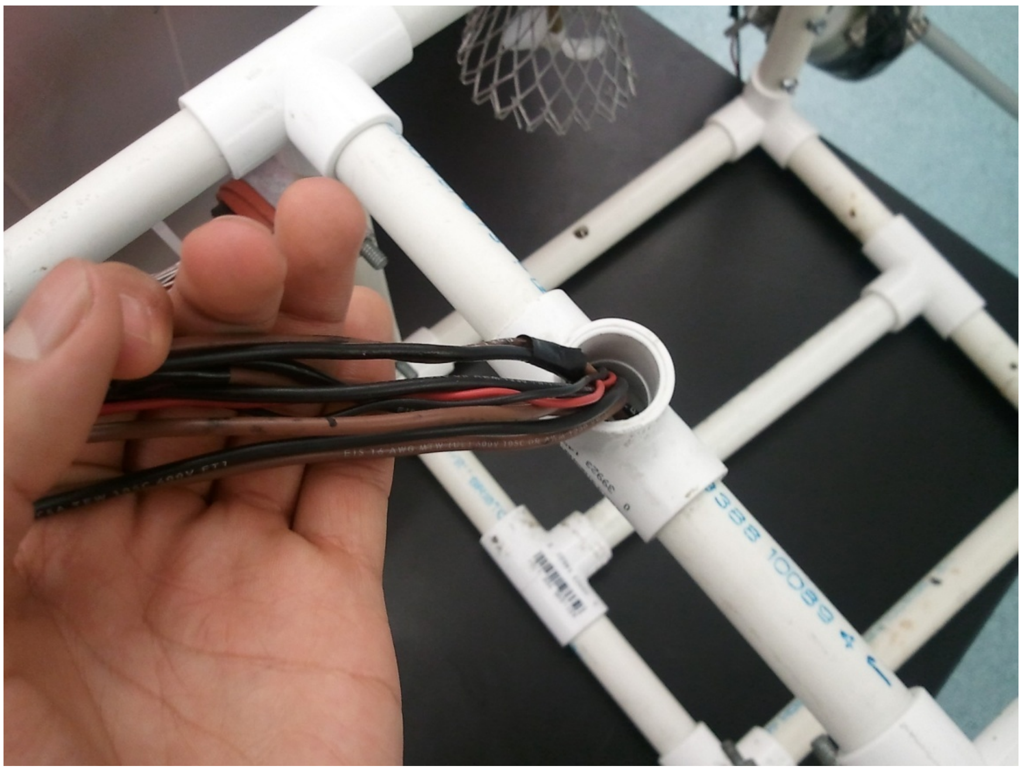
Depth Gauge: To measure the depth of the water sample, we used a store-bought depth gauge. Because we depend on the cameras to see the depth measurements, we added our own markings to the gauge to improve visibility.

Water Sampling: To take a water sample from the bucket we created a hydraulic pump system made of two plastic 60 cc containment syringes and manually powered by a 60 cc syringe on the bot and on the deck. Extending from the sampling syringe is a tube with a sliding funnel at the end, which guides the sampling tube into the pipe to ensure a complete and accurate sample.

Gripper: This year, we knew it would be important to have a multipurpose gripper on our ROV that could remove the damaged riser pipe, carry and place the cap to the oil well, and assist us in collecting the biological samples. The arm was designed to be completely waterproof and strong while still exhibiting the simplicity necessary for troubleshooting. To make the arm, we cannibalized a hand-operated trash picker. The trash picker consisted of two grips on the end, which were attached to a metal chord that, when pulled back, would push the grips together. We used a similar concept in building our arm, although instead of pulling the chord back by hand, we wrapped it around the rod connected to a high torque, 40 rpm motor. As the bar spins, it either shuts the gripper or pulls it open. The motor itself is waterproofed, sprayed with WD-40 and potted in a plastic container filled with strong epoxy.

Secondary Motor: To turn the valve wheel to stop the flow of oil, we used another motor-powered system on the back of our ROV. We built this payload by connecting pieces and joints of PVC pipe to form a forked shape with the fingers separated by the necessary distance to fit into the wheel. We then attached the back of this piece to the end of a 40-rpm motor using steel clay. As the motor spins, the PVC spins the wheel with it.

Tether: The tether compromises of wires, a wrap around plastic sheathing and positively buoyant polyurethane caulk saver. The wires are insulated and are tied together at various points via zip ties. These wires are then twisted along with polyurethane. The wire and polyurethane are encompassed within a plastic sheathing. We chose to have a positively buoyant tether (Due to polyurethane) as it will not obstruct the bot. The plastic sheathing keeps everything neatly tied up. Buoyancy of the ROV and tether: The ROV is neutrally buoyant and the tether is positively buoyant. With the ROV neutral, the ROV remains in place and the tether floats above- therefore not obstructing the ROV.



Challenges

A major challenge that we faced in the process of building our ROV was waterproofing a motor that would spin, with PVC pipes sticking out of it, in order to rotate the valve. This was a very patience oriented task. We had to use steel clay, and a lot of epoxy to make sure no water affected the motor when it was submerged underwater. The first time we did it, we stabilized the motor inside the contraption, using the steel clay, and we let it dry for the day. Then unfortunately we had a problem with the wires that were attached to the motor. The wires kept falling off because of poor soldering. That slowed us down as the small wires were very hard to solder to the small motor. After that, we had to find a small enough container that would be a nice fit for the motor to sit in. Once we had the clay dry and the soldering done, we quickly made the epoxy. However, when the epoxy dried after five minutes, we tested the motor out and it wasn't spinning. The epoxy had somehow gotten into the actual motor, which froze the whole motor, thus not spinning and not being functional. In order to combat this challenge, we had to get a new motor and make it again. This time we decided to put the epoxy inside the container first, and then placing the motor inside. We decided to do this because we figured out that putting the epoxy inside with the motor, could spill onto the spinning part of the motor, thus not allowing the motor to spin with hardened epoxy in the way. We also decided to always double check the wires, to make sure they are stable and that they won't fall off. It was a very important lesson for us, because we had not planned accordingly and it resulted in a waste of work for 2 days.

Skills Gained and Lessons Learned

The mindset of running a business and the mindset of engineering on a limited budget have one major element in common; they both value efficiency and resourcefulness above all else. Last year, our ROV's design was too elaborate, and as a result we suffered from a loss in practicality and a more complicated troubleshooting process. Our digital controls and camera setup were too difficult to maintain and troubleshoot, causing significant setbacks and an overall loss in performance on the day of the competition. This year, we returned to the design stage with our previous problems in mind, and decided to build an ROV that was not only capable of performing the assigned tasks but capable of performing them without the use of unnecessary resources. While this may have been a simple goal, accomplishing it was more complicated. The team developed its skills in many different ways to channel the group's efforts into a simple and effective ROV, and over the course of the project, while our technical abilities improved, one of the most important skills developed and refined during the ROV's construction was our group's ability to create a machine capable of working simply, practically and harmoniously.

Troubleshooting

To make troubleshooting easier for our team, we kept each system as simple and independent as possible. We kept our controls analog, our tether loosely held together during the early build process, and our physical components operated by many identical simple motors. Thus, when different parts broke or were not as effective as we had hoped, it was easy to either make small changes to the systems, or rebuild these components completely. For example, we were able to rebuild the motor-operated component on the back of the ROV (used to turn the oil-well wheel), using the same kind of motor and adjusting small details in the design such as the material we used to hold the motor shaft to the PVC fork. We were also able to replace a faulty propeller and adjust the controls of last year's propulsion system.

Future Improvements

For the coming years of CRLS's ROV team, there are some changes and improvements that can be made. In the future, we can work to have a more systematic approach towards getting feedback from team members, dividing up tasks, and organizing information. Keeping the designs of the ROV's frame and payload tools simple is another goal, as we want to have little clutter and maximum efficiency. Another improvement regarding the technical aspects of the ROV could be the use of joysticks and a digital control system for more precise and sensitive controls. We want to use materials that are lighter, thus reducing the load on the motors. We also would like to continue recycling materials that we use from year to year.

Reflections

Simran: Constructing an ROV to accomplish tasks modeled after real world incidents was an interesting and informative experience. I enjoyed working with and learning from my teammates. This experience has taught me more about electronics and robotics, opening new career paths for me, all while still having fun!

Alex: As captain of the team, I was met with newfound responsibilities. However, I enjoyed my experience and value it greatly. I enjoyed working with fellow team members and have learned a great deal from each. I've acquired more skills pertaining to robotics, and also gained substantial leadership knowledge. This has been a great year for the team and I am proud.

Amy: This has been a very rewarding experience. I've learned many new technical skills, and also expanded on my knowledge of robotics and real world applications of ROV's. I enjoyed working with my fellow team members. I've made new friends, gained knowledge and had fun as well.

Eric: I've learned a great deal from this year's competition. The connection between the oil spill and the ROV competition has opened new applications of robotics and engineering. I found the tasks to be challenging yet also engaging and exciting! Overall, I am very happy that I had a chance to participate and had a great time!

Imtiyaz: Participating in the MATE ROV competition was a fun experience. I have learned a lot, and gained new technical knowledge. Designing payload tools for specific tasks was challenging but also rewarding. It was also great to work with fellow teammates and mentors.

Jonah: Working on the ROV was an interesting job. This experience has taught me more about robotics, engineering and it's applications. I've also learned a lot from my teammates and greatly enjoyed working with them.

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Company that sponsored our team and gave us funds to help us reach the International Competition

The Pile Drivers Union (Company)
Company that sponsored our team in order to fund for the international competition

MATE (Host)
Allowed us to compete and achieve first place in the New England Regional Competition with a contribution to go to the International Competition.