Robotec

RFP-VN120-12345 PROTOTYPE DESIGNS FOR AN AUTONOMOUS UNDERWATER REPAIR ROBOT

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Robotec is a team of mechanical, electrical and software engineers specializing in affordable, tailored, and efficient robotics. The engineers assigned to RFP-VN120-12345 are Marc Descoteaux and Omer Salihovic along with their assistant colleagues who will assist in specific areas of the build.

AUV Development

The University of Victoria's Ocean Networks Canada operate the VENUS and NEPTUNE project observatories providing vital research. They have underwater forensic cameras that provide live video feeds of conditions related to the ocean floor, water quality, and seismic activity. Falling debris periodically covers and obscures cameras and sensors interfering with feeds and data collection. We will be needing an autonomous underwater robot able to remove this debris to ensure accurate findings and swift completion of projects.

The robot should

- Find debris in the search area
- Remove the debris
- Leave the area to signal retrieval upon completion

It must be able to

- Operate in the given search area
- Remove debris of varying weights (up to 450 grams)
- Avoid causing any undue damage to the environment

Other autonomous underwater vehicles (AUVs) have been in development for other purposes. The Machine Lab have constructed similar robots (see figure 1) for the Department of Mechanical and Manufacturing Engineering at the University of Calgary, the US military, and the Department of Geosciences at Pennsylvania State University. They all share the purpose of retrieving samples or collecting data through remote control.

Figure 1: Custom research robot from Machine Lab [1]

Elsewhere, Robot Technology Inc. was contracted by DARPA to construct a long range robot with a heavy duty arm to assist on missions. The Energetically Autonomous Tactical Robot (see figure 2) does not require to be refueled as it gathers fuel through biomass.

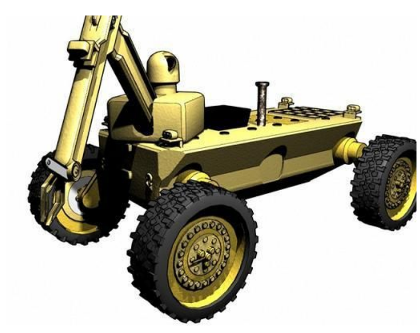

Figure 2: Energetically autonomous tactical robot [2]

The RAUVI project conducted by Jaume I University created a swimming robot with an arm (see figure 3) which was capable of retrieving a downed black box. After researching these projects, we've come up with two proposals utilizing Vex Robotics kits. Aspects of the Vex implementations will be drawn from these successes.

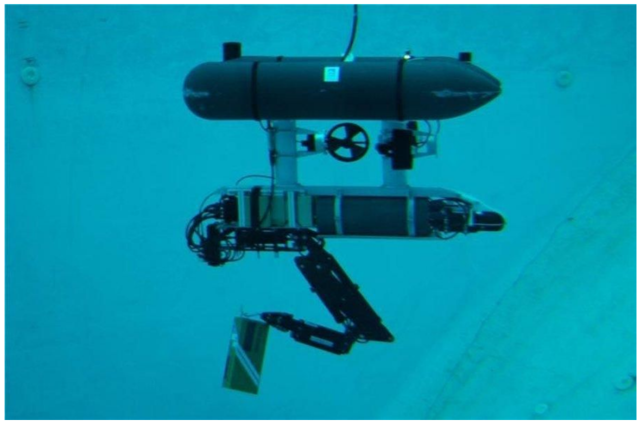

Figure 3: Reconfigurable autonomous underwater vehicle for intervention [3]

Master Hand

In order to adhere to the given objectives and constraints, the concept design will focus on explaining the structure of the robot, materials used in construction, movement mechanisms, sensors, and controls. The concept sketch is shown in figure 4.

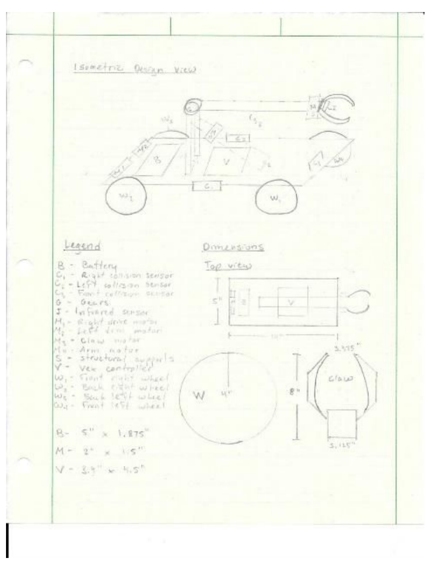

Figure 4: Concept sketch of Master Hand with dimensions

Structure and Materials

The Master Hand will be a clawbot. It will have four wheels and an arm attached to the body. The body will house the motors and battery at the back. At the center of the robot will be the Vex Controller and the tower for which the arm operates. At the end of the arm, the robot will have an adjustable claw for retrieval, and a sensor for identification of debris. Along the front and sides of the robot will be multiple sensors for obstacle avoidance. All materials used will be supplied by Vex Robotics.

Movement Mechanisms

The robot will be powered by a 7.2V battery connected to the VEX Controller. It will have four motors. Two motors will control the left and right drive wheels at the back with the front wheels independent from them. Gears will be placed at the top of the tower to connect the arm. It will be translated up or down with one motor until level with the debris. Once aligned and identified by the sensor, the last motor will close the claw to retrieve the object.

Sensors and Controls

The robot will be controlled by RobotC code through the Vex Controller. The sensors on the front and sides are to make sure it stays within the search area and avoid any collisions with the environment to avoid any undue damage. The infrared sensor on top of the claw will be searching for the debris. Once in range, the sensor will signal the claw to contract an object up to 450 grams and then signal the robot to leave the search area.

Annihilator

The Annihilator will be reviewed the same as the Master Hand. The concept sketch of the Annihilator is shown in figure 5.

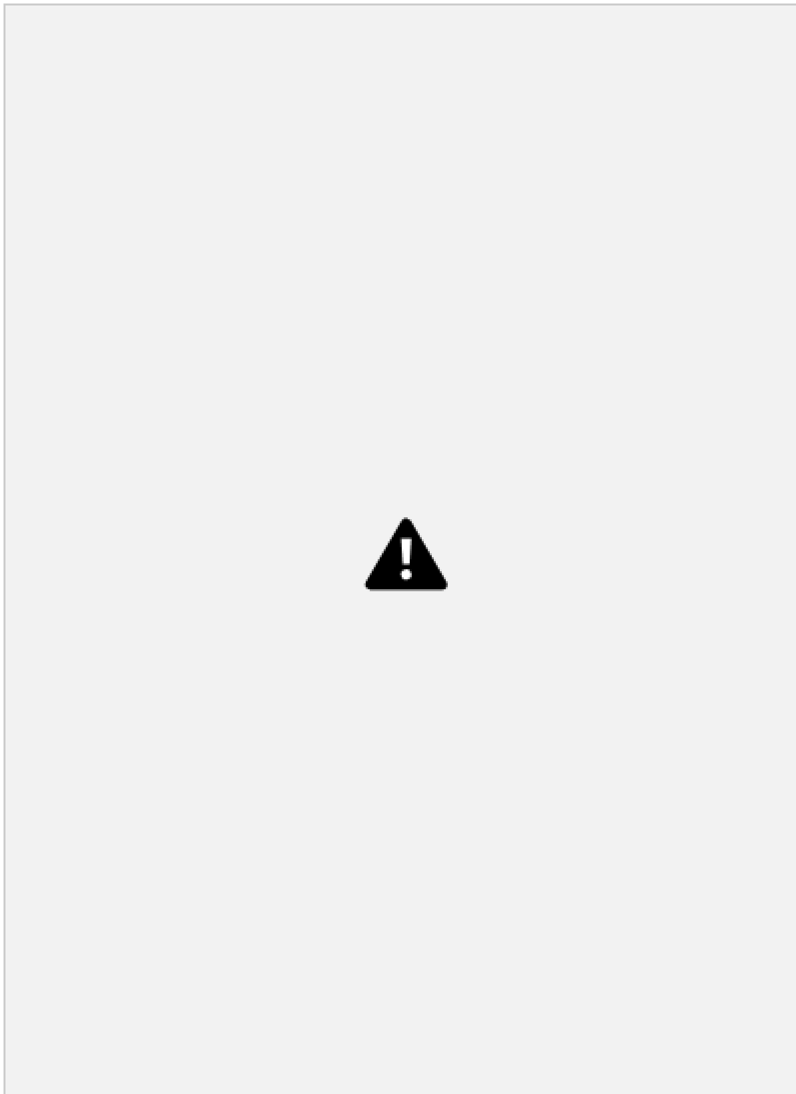

Figure 5: Concept sketch of proposed VEX solution 2. Sketch includes parts and sketch of forks.

Structure and Materials

This robot will resemble the EATR with its structure. It will have four wheels, but instead of an arm to pick up an object, it will use forks like ones found on a forklift. The body will house the motors at the back while the battery will be mounted to the undercarriage of the frame. At the center of the robot will be the Vex Controller. At the front of the robot, it will have a fork that will lift vertically and be controlled by one of the motors. If chosen by the client, an additional tilt feature can be enabled as well, controlled by a fourth motor. At the front of the robot, there will be a sensor to detect the height of the object. Bumper switches attached to the front left and right corners of the robot are installed to provide harsh obstacle avoidance. As well, in the rear of the robot, there will be limit switches which will act much like the bumper switches. All materials are still supplied by Vex Robotics.

Movement Mechanisms

The robot will be powered by a 7.2V battery connected to the VEX Controller. It will have three to four motors. Two motors will control the left and right drive wheels at the center attached with a shaft that goes to a gear which is connected to two more gears on each wheel. This is done on both sides. Gears or a pulley will be placed just behind the fork back plate to allow vertical lift. One motor can do all the work, unless the client decides to add the optional tilt option. The sensors will detect the object and secure it. Once found, the robot will back out and leave the area.

Sensors/Controls

The robot will be identical to the first proposed solution which is controlled by RobotC code through the Vex Controller. The sensors and switches installed on the front and rear of the robot are for obstacle avoidance with harsh collisions in the delicate environment. The infrared sensor at the front is to detect the height of the target when lowering the object onto it, and signaling the robot when to back out and retreat the search area.

Materials/Labor Cost

There will be a cost of hiring multiple engineers which is broken down in table 1. As well, the materials used for the build will be the vex kit, sensors and any additional parts bought. The cost breakdown is included in figure 6.

Table 1: Hired engineer costs

Tasked Engineers	***Time on build (Hours)***	***Hourly Cost ($)***	***Total per Engineer ($)***
Mechanical	25	80	2000
Software	20	70	1400
Electrical	15	65	975
Grand Total		4375	

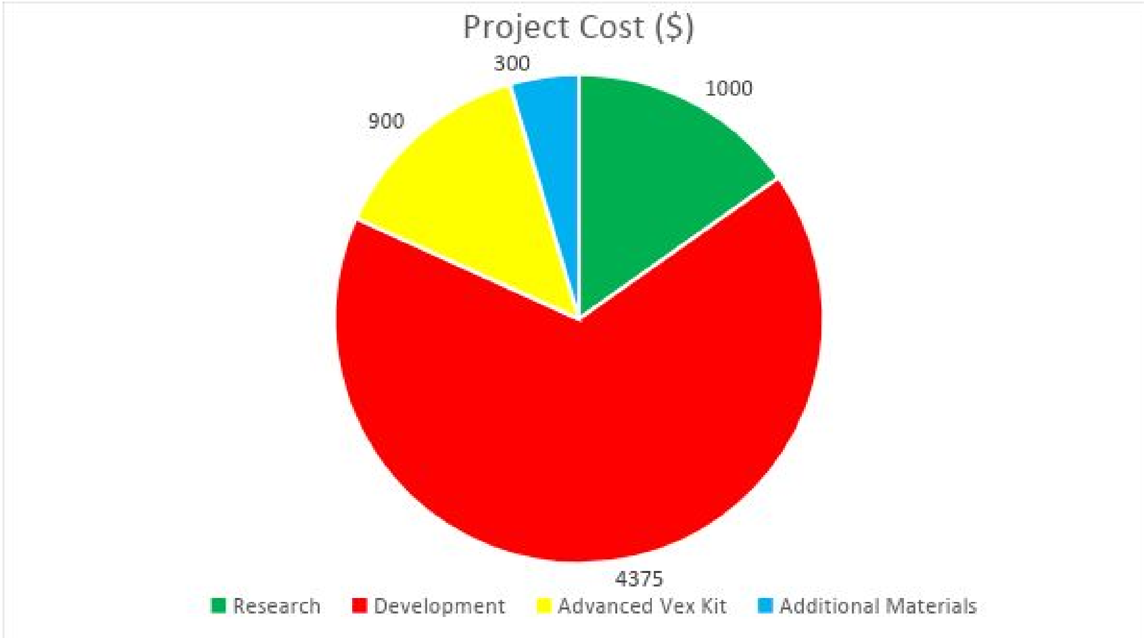

Figure 6: Project cost in a Pie Chart

Project timeline

The milestones for the project are represented with a Gantt chart and table that outline the project from the commencement of the build in January to completion in March (see figure 7/table 2).

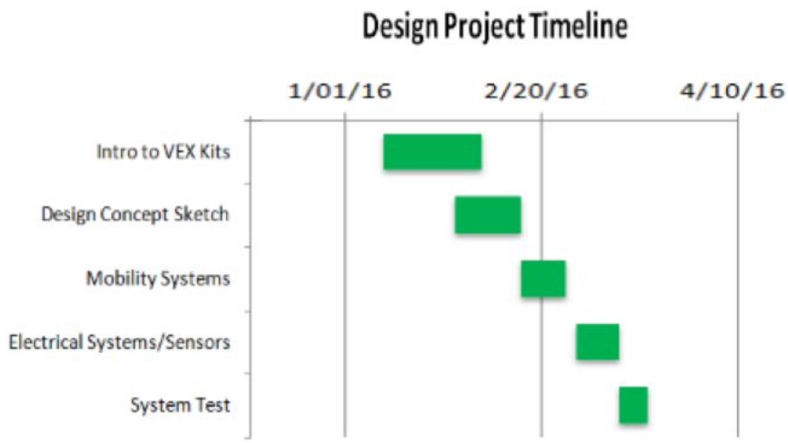

Figure 7: Gant Chart of project timeline

Table 2: Outline of project

Task	*Start*	*End*	*Duration (Days)*
Intro to Vex Kits	1/11/16	2/05/16	25
Design sketches	1/29/16	2/15/16	17
Mobility Systems	2/15/16	2/26/16	11
Electrical and Sensor Systems	2/29/16	3/11/16	11
System Tests	3/11/16	3/18/16	7

Recommendation

The Master Hand has many advantages. It has multiple sensors along its core body that will prevent damage from occurring to the fragile marine eco system. Its claw is an excellent solution to clearing debris from the area, with the ability to grasp onto objects up to 450 grams. Its powerful battery will sure to last the whole mission and have no issues with heavier objects.

The Annihilator is also very advanced with its many features. Similar to its counterpart the Master Hand, the Annihilator has many sensors on its frame, as well as bumper and limit switches for extra insurance. The bumper and limit switches are in place in case of a sensor failure, which will still provide reliability to avoid damage to the delicate environment. With the Annihilators advanced options, the customer is sure to be able to find a combination to suit their needs. Overall, the Master Hand and Annihilator are both great solutions to the problem, and whichever design is chosen, will do the job at hand with ease and return the investment needed proving to be a great business venture.

References

[1] Machine Lab (May 2008). *Research Robot* [Photograph]. Retrieved February 21, 2016. Available: http://www.themachinelab.com/Custom/Calgary/Ucal40-3.jpg

[2] Robotic Technology Inc. (April 2009). *Energetically Autonomous Tactical Robot* [Graphic]. Retrieved February 21, 2016. Available: http://www.robotictechnologyinc.com/index.php/EATR

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[4] M. McGuire, “Prototype Ocean Floor Robot Design Project,” Dept. of Engl. & Fac. of Engr., Victoria, B.C., pp 5, 2016.