Cost Effective Robotics: Using VEX Robotics Kits

By Arthur Dutra
"Gus" Robotics Team 228 – www.team228.org

For rookie teams and many veteran teams alike, finding enough commercial sponsors and enough space to host their team can be two very formidable challenges. Many teams face limited budgets and constricted work environments. Although one may make the argument that these conditions exist in the real world, there are solutions. This solution comes in the form of the Vex Robotics Kits. Turning to personal experiences from my personal Vex kit and the WPI Frontiers Vex competition, the ideas in this white paper have came from actual Vex robots and scale playing field components. As a side note, this white paper will not go into the exact nuts and bolts of how to build or program Vex robots, but rather some of their many possible implications in FIRST.

» Prototyping Ideas

Other than the FIRST Vex Challenge, the Vex kits themselves will prove very useful to the high-school FIRST Robotics Teams. As already stated, there are many teams that barely have enough money each year to continue to participate in FIRST. So when it comes to the build season, these teams might not have ample budgets to buy large quantities of materials for testing and prototyping ideas. Here is where Vex comes to mind. By their nature, the "erector set" like properties of the Vex kits make them ideal for prototyping ideas. Instead of possibly spending days building a prototype robot and mocking up ideas, a simple Vex robot can be built within hours. Rather than machine parts and use up valuable raw materials, Vex metal components can be bent or cut in seconds. Parts can be bolted on and off quickly. Ideas and innovations can evolve faster, allowing for many more ideas to be built within a small amount of time than other wise possible.

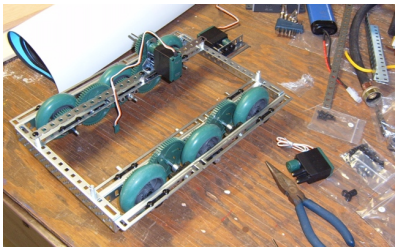

Figure 1.1 - Does your team want a six wheel drive robot? Or was that four-wheel drive? Maybe tank drive is on your mind. Or would you like to test an omni wheel robot? All of these can be done easily with Vex, as the early six-wheel drive Vex robot show above shows.

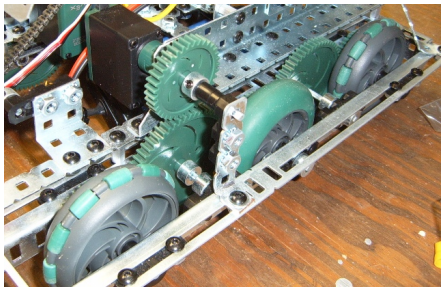

Figure 1.2 - Later on, omni wheels were tried out on my Vex robot. With a full size robot, this would mean ordering omni wheels online (or fabricating your own), waiting for them to arrive, and installing them. However, with Vex, wheel and gearing combinations can be changed in minutes.

» Scale Building

But before we dive into our new Vex kits and start building mini FIRST robots, we need a scale. After some experimentation, 1:3 (one third scale) was deemed perfect. This would make the maximum Vex robot dimensions roughly 9.5" by 12.5" by 20" by the 2005 rules. This works out perfectly; since that is exactly what the dimensions of the frame I used (Figure 1.1). The only parts that needed cutting to make this basic frame were the (four) 90° angle pieces. The short four inch stubs off these pieces were later used on the elevator. Six of the small (2.75 inch) wheels were used, since they were the closest to the one third scale used.

» Drive Systems

On a full size robot, changing from a six wheel tank-drive to an omni-wheeled holonomic drive can require significant effort. But once again, the simplistic yet sophisticated Vex kits triumph over this. Using their simple bolt-on/bolt-off parts, one can change from almost any drive train combination to another in anywhere from a few minutes to a few hours at most. Also, as John V-Neun and Chris Carnevale of Innovation FIRST have demonstrated (Figure 1.3); even swerve (crab) drive robots can be built with Vex components.

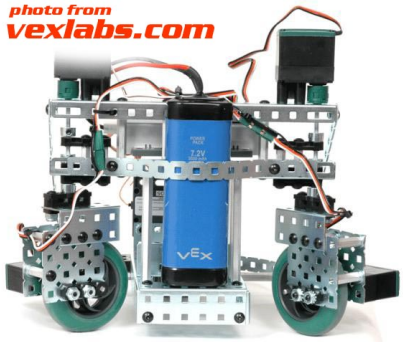

Figure 1.3 – As illustrated in this picture, no idea for a robot drive system is beyond the limits of Vex-only parts. This robot was built by John V-Neun and Chris Carnevale at Innovation First.

» Arms, Elevators, and Manipulators

But the amazing abilities of Vex kits do not stop at making prototypical drive trains. Using a host of Vex components, including the chain and sprocket, additional gears, motors, servos, and Vex compatible pneumatics, almost anything can be built out of Vex parts. For my Vex robot, I wanted to mimic my team's 2005 robot, which included a single stage elevator set at roughly a 10° angle and an arm on top of that. As

illustrated in Figure 1.4, both of these were achievable with Vex-only parts. (No other non-Vex parts were used, making this entirely FIRST legal). The Vex Chain and Sprocket set proved priceless in creating both of these. Not only did it allow for the "continuous" loop elevator, but also simplified the gearing of the arm. Although the actual needs may vary, remember that arms and manipulators often need more torque and less speed than a drive train, so they must be geared slower.

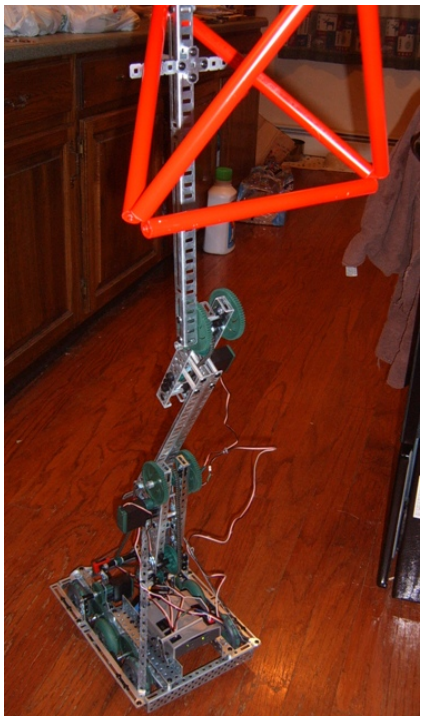

Figure 1.4 – In the above picture, the elevator is a single stage with roughly 11 inches of travel. The arm is built off the upper portion of the elevator, and can rotate about 270°. As with the rest of the robot, everything is 100% Vex only parts. But wait, is that a real 1:3 scale tetra?

Another one of the useful components of the Vex kits that allow for easy replication and prototyping of ideas are the Vex-compatible pneumatics available from Innovation FIRST. They allow for relatively light-weight, linear motion devices that can be used to power a wide range of manipulators.

» Saving Space, Saving Money

One of the greatest advantages of using Vex robots over a full-size prototype robot is the space saving involved. As Figure 1.4 shows, smaller versions of playing field components are not only possible, but much cheaper. At one-third scale, an entire 2005 playing field would be nine by eighteen feet. And the price is also drastically lower.

» Building Small, Building Cheap

One full size tetra for the 2005 game may have cost over ten dollars per each; a one-third scale tetra only costs about one dollar. These 1:3 scale tetras were made out of ½" CPVC. With one-third scale components, a 2005 goal assembly (made using ½" EMT) costs about $2.25 per goal. Simple refrigerator magnets were used to make the hanging tetras. (Note: if the magnets were too strong, glue a thin plastic cover over the magnet to weaken the strength). To build all nine goals and sixty tetras would cost about $80 dollars.

» Driver Training

Teams will still need several full-size playing field pieces, goals, and other components. But for teams whose space and money are restricted, having half or an entire field in one-third scale can reap infinite rewards. Once a team has a design for their full-size robot, an exact copy using Vex parts can be made within days. For me, it took about 12 hours to build my entire Vex robot (Figure 1.5). If you build your Vex robot to a scale speed to your full-size robot, this now opens the doors to driver practice. Now, while the full-size robot is still being constructed, drivers can drive the mini Vex robots around the field. Imagine being able to have drivers drive mini, yet fully functional robots around a scale field in only the second week of the build season. For larger teams, this may be possible, but for the majority of medium to small FIRST teams, this reality is now feasible with Vex.

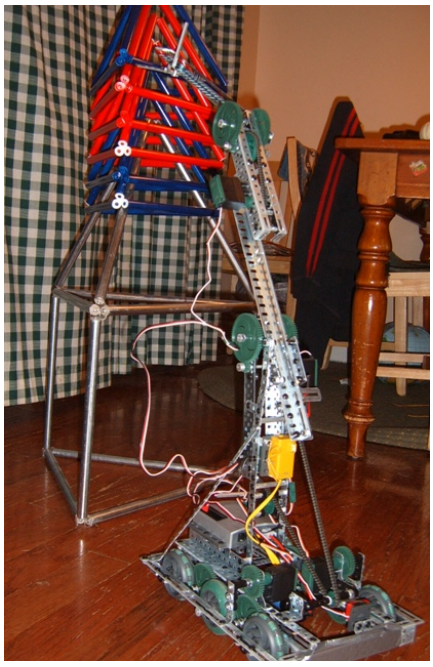

Figure 1.5 – Yes, that is a real mini tetra! And wait; there is even a mini center goal. I built six regular tetras, two vision tetras, two hanging (magnetic) tetras, two regular goals, and a center goal. Here are some of the tetras on the center goal.

» Strategy, Strategy, and more Strategy

When the buzzer sounds at the beginning of each match, the winner of the game will depend as much on a solid strategy as excellent robot design. For teams that are unable to build multiple robots to practice with, their ability to form a solid strategy may be hampered without actual testing. Yet with Vex, new possibilities are opened. Now, one can fit an entire FIRST field into a single classroom. And with the reduction in costs, comes the possibility to build multiple mini Vex robots. Teams may decide to build two, three, four, or possibly even six different Vex robots for the price of one full-size additional practice robot. Teams can then have six different students drive all six different robots at once on the mini field, simulating an actual match. This may prove very helpful when developing strategy, as now one can see just how a certain strategy may play out.