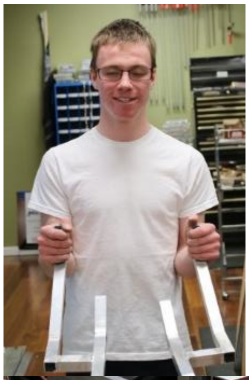
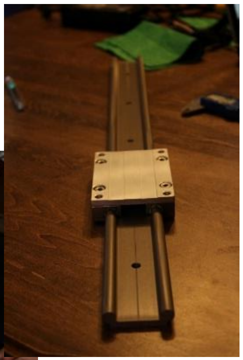
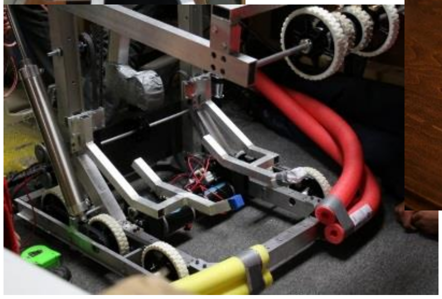
Platform Design

One of the more interesting subsystems of our robot is our platform for the ball. Our platform allows us to raise the ball up and down when it is inside of our robot, which means that our kicker can hit the ball at different angles. With the platform our robot can kick the ball in any direction ranging from straight out the front to nearly vertical.

When our team settled on using a kicker for shooting the ball we realized that we needed the ability to shoot the ball at multiple different angles. Shooting into the goal, passing to alliance members and shooting over the truss all presented different challenges that a constant position kicker couldn't solve. We realized that depending on where the kicker hit the ball we could infinitely vary the angle that the ball was shot from. Having a platform that can raise and lower the ball allows us to achieve our goal of having multiple ball trajectories as well as holding the ball against the intake mechanism to prevent it from freeing itself from the robot.







Our platform is articulated up and down by a snow-blower motor that runs belts the platform is attached to. The snow-blower can't be back-driven which allows us to hold the ball at a constant position as well as giving us plenty of torque to move the ball. The belts provide

The Highlanders

Carbon Fiber Engineering Design

Carbon Fiber on The Highlanders Robot:

· This season the team constructed carbon fiber tubing, solid carbon fiber sheets and carbon fiber sandwich sheets (plywood core and foam core) from raw carbon fiber fabric and epoxy in our own shop.

· No one on the team had any prior experience working with carbon fiber before January 2014.

· The team did a great deal of online research about carbon fiber. Our research included both how to create carbon fiber parts from raw carbon fabric and epoxy as well as how to safely handle, cut and machine finished carbon fiber parts. We particularly did our homework on the safety aspects including: handling and cutting raw carbon fiber fabric, layup and epoxy construction (and cleanup) in a small shop,, safe handling, cutting, drilling and sanding of finished parts.

Carbon Fiber applications on the robot:

Rectangular carbon fiber tube:

- We created three mechanism.
- The "intake arm" on pieces of aluminum approximately 20" of pieces) with custom

Carbon fiber tubing was the outer dimensions of long and each replaced lugs at each end.

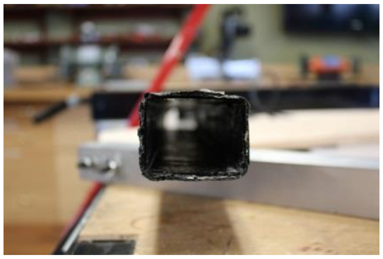
pieces of carbon fiber rectangular tubing for the "Intake"

our early prototype robot was made by welding three 28" tubing together. In our final robot we replaced the aluminum tubing (from the middle of each of the three built carbon fiber tubing.

constructed with an inner cross-sectional dimension equal to the aluminum tubing. Each carbon fiber tube was about 26" approximately 20" of aluminum by overlapping aluminum

Solid carbon fiber plate:

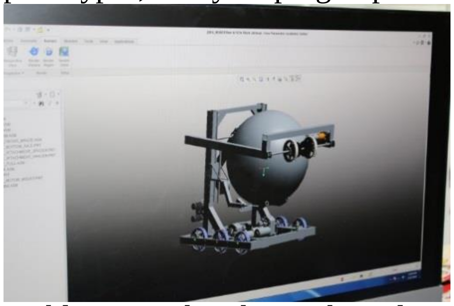
- We created two carbon fiber plates to line the bottom of the robot and support electronics components, drive motors and our air compressor.
- Carbon fiber sandwich plate (plywood core) :
- A large plate of sandwich construction carbon fiber plate was created to hold electronics components and kicker foot at the back of our robot. The plate is vertically oriented and bolted along its outer edges to two vertical aluminum rectangular tubes which themselves are bolted securely to the base of the robot.



a solid linear motion without a wildly difficult mechanism and we learned how to efficiently use the belts for linear motion on our robot last year. Our platform is a solid mechanism that adds a level of flexibility to our robot in order to accommodate changing circumstances on the field.

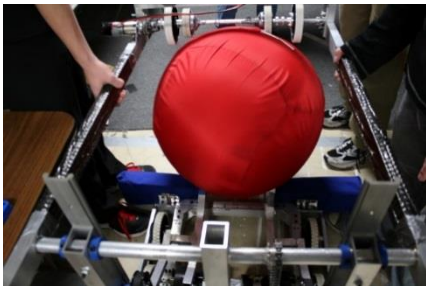
Intake Design

Our team's intake mechanism evolved over multiple design phases and incorporated lessons that we learned as well as input from other teams on Chief Delphi. At the beginning of our season we first decided to use wheels to pull the ball into our robot because it was easy to prototype and we had the stuff to do it on hand. By the end of the first weekend of the build season we had a working prototype using a cordless drill and some wheels that we had left over from the prior season. It worked great and was one of our team's first working prototypes, really helping to put the season off to a great start.



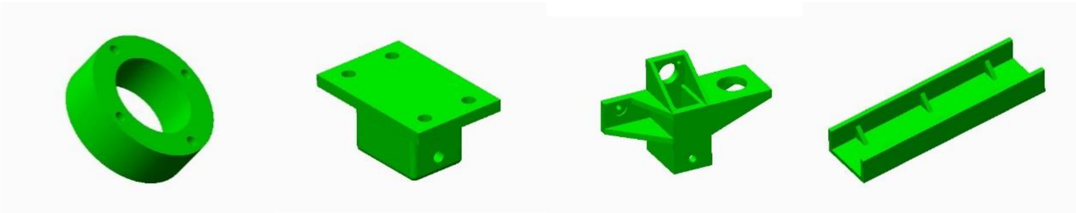
The first robot that we made used the same system that we had developed in our prototype, with wheels and a motor pulling the ball into the robot. The wheels were held out in front of the robot by an arm that pivoted at the top of our robot's towers. The intake was actuated down by a pneumatic piston to pick up the ball and was raised back up in order to shoot and remain inside the frame perimeter. The problem was that the intake only seemed to push the ball away because the wheels were behind the center of the ball, not in front of it. The other problem was that the intake rotated on the same pivot as the kicker and because the bushings that we used were poorly lubricated and designed it took a considerable amount of force to turn. When we considered our robot's strategy we also learned that even with the intake in its highest position we couldn't kick the ball straight up, which we considered vital to our ability to kick over the truss.

The final design that we settled on was based on our prior designs as well as the feedback that we had received on Chief Delphi and it was by far our best. We moved the pivot point of the intake mechanism to the bottom of the robot rather than the top to make extending to the desired distance easier and our mount solution stronger. We also decided to use the Igus slew rings that we had received in FIRST Choice because of the superior strength and reliability that they offered us over traditional bearings and bushings. The intake used rubber wheels that we had ordered from BaneBots, which increased our grip on the ball and our ability to pull it in. The intake also now extended in front of the ball, again making it easier to grab the ball. The same pneumatic piston was used to pivot the intake arm, but the forces on it were reduced in our new design. The design that we had developed was simpler and stronger than the ones that came before it and provided our robot with a reliable system to catch balls and integrated well with our other subsystems.



3D Printed Parts Design

Many of the parts on our robot are 3D printed because the 3D printer can make parts faster than the manual machines when strength and size are not of extreme importance. Many of the spacers on our robot as well as the mounts for cameras, lights, and electronics are 3D printed because it is simply faster to do them on the 3D printer and they do not need the strength gained from aluminum or steel. Our team's acquisition of a 3D printer has been a huge help this season and our robot is cooler-looking and easier to make because of it.



The Highlanders

The Kicker

Engineering Design

Kicker Design

When it came down to how our team was going to shoot the ball into the goals on the field everyone came up with a number of great ideas. During the first weekend after kickoff the shop was filled with numerous different prototypes and ideas about how we could shoot the ball. The two main ideas that were proposed involved making a catapult to launch the ball as well as a kicker that would hit the ball after swinging in a circle. The kicker proved easier to prototype as well as to make and it provided a number of different advantages including the ability to change the energy with which we hit the ball and the angle that we hit it at.

Our first kicker design involved a ToughBox gearbox and two CIM motors for power and kicker foot that we had made from wood, duct tape, and a number of steel blocks. The kicker pivoted around an aluminum tube held up in bronze bushings. The design was mechanically very easy to make, but the bushings simply ground down the softer aluminum tube and friction became a major problem.

The final design for the kicker that we settled on replaced the bushings with bearings in order to reduce friction and used a shorter hex axle to reduce the bending problems that we had seen with the aluminum tube.

The kicker also used an aluminum foot that we curved using the CNC machine to make our design simpler and better looking than the

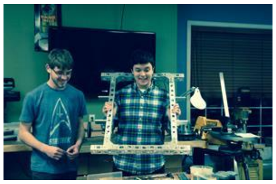
The Highlanders
The Chassis
Engineering Design

History:

Our team's chassis has been a long process that has taken many months of design work both before and during the build season. In last year's competition we used the standard AndyMark chassis with C-Channels and Toughboxes. Our team's twist on the design was our use of meccanums with the AndyMark chassis, but this had a number of drawbacks. First, the frame wasn't sturdy enough for mecanum wheels and because of this we couldn't maneuver like we had expected the mecanum wheels to be able to.

Usually one wheel was higher off the ground than the other three and when we tried to move sideways the robot either didn't move at all or just turned in circles. We also learned that we needed to use shifting gearboxes with our robot in order to gain both an advantage in speed and torque with our robot.

The first big step in creating our team's custom chassis occurred at the end of summer break when our team purchased its first CNC mill. One of the first things that we tried to do with it was to cut out a truss pattern into the side of an aluminum tube.



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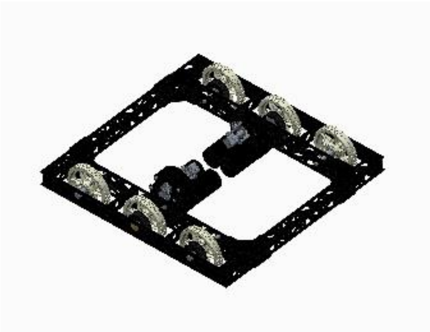

When the challenge was released on January 4th, our team, like every other first team, began to frantically strategize and discuss what our drive base options were and what we wanted to use. We did eventually settle on a six wheel drive base with two-CIM ball-shifters, but the exact configuration and design of our chassis was still unknown. Some of us wanted to use the standard AndyMark chassis or a chassis made from AndyMark NanoTube, while other favored making our own like had discussed in the pre-season. After much deliberation we did eventually settle on making our own, even without a completed design. Our CAD team then focused for the next two weeks on designing the full chassis with shifters and all from scratch and by the end of week two we had done it. Our chassis very closely resembled the one that we had tried to design during the pre-season, but it had a few major modifications. First, we

borrowed the wheel configuration of the standard AndyMark chassis, using a live axle from the gear box for the center wheels and dead axles for the front and back wheel to reduce the complexity of the overall design. We put the wheels and belts in the same place as on the AndyMark chassis and used dropped center wheels to increase our maneuverability. The rest of the chassis bore a striking resemblance to the one that we had designed in the fall with aluminum tubing comprising most of the structure and Vex Pro Ball-Shifting gearboxes providing power to each side of the robot.

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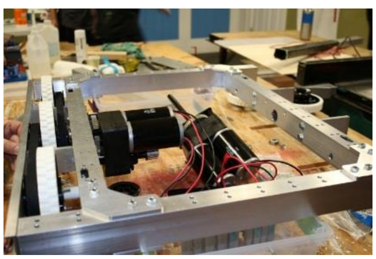

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The structure of our chassis is relatively simple compared to other team's custom chassis and was designed with the equipment that we had in our shop in mind. Everything is either made from aluminum tubing or plate that we buy from a sponsor in town. We used 6061-T6 aluminum for its superior structural properties and its ease of machining, but we did have to custom order some stock because it wasn't stocked locally. The tubes are held together at the corners with ¼ in. gusset plates that we machined using the CNC machine. While heavy, the gusset

plates add a superior level of rigidity to our robot what we couldn't have otherwise gotten with lighter plates. The extra weight of the gusset plates was more than made up for with the CNC sequences that we ran on the aluminum tubes. We put weight saving trusses and squares on all four sides of the tubes and we even put a standard hole-pattern on the top of all the beams in order to make mounting our robot subsystems easier. Our wheels were held in place using 3D printed spacers that both saved weight on the robot and reduced the time that we had to spend using more work-intensive machines like the mill and lathe.

Each of the tubes on our chassis is 26 in. long and we used our CNC machine to remove metal from nearly the entire duratio n of the tube, but we were just barely able to do this because our machine has a maximum travel of 27 in. All of

our sequences for running the CNC machine were made using the NC part of Creo provided by PTC. We used a variety of end mills to machine the beams, ranging from 3/8" roughing bits to ¼" finishing bits in order to reduce our machining time. After each of the parts for the chassis was done we sent them to another local sponsor who powder-coated them for us.

When we assembled the powder-coated chassis for the first time the weekend before bag-and-tag it was an incredible moment for our team. Seeing the chassis driving around for the first time really justified all the work that we had all put into it. We don't know what we will do next year but we are looking forward towards the challenge.

wooden duct-taped foot that we had used previously. The new design used the same motors and gearbox as before, but was mechanically far superior to our first revision.