eTREC Robotics 6977

Engineering Notebook Team Section

Meet Our Team Members and Mentors!

Meghan

Hi, my name is Meghan, I am a junior in high school, and this is my forth year doing FTC. I am the team's public relations rep, as well as the head programmer. I really enjoy going through the design process, and seeing my ideas come to life. When I'm not designing and building robots, I am most likely horseback riding. I have been riding for 14 years, and I love it just as much as I love engineering. I ride competitively on my school's Equestrian Team. In school, I enjoy challenging classes in science and math. I also love books.

Meghan

Tim

Tim

Hi, my name is Tim, and I'm a senior. This is my second year doing FTC. I have been to conserve school and montessori school and I live on a farm, so I have had a lot of experience doing hands-on things. I am currently taking IT courses at Gateway Technical College. I am also good at math. Outside of robotics, my other interests include music, computers, and video games.

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Ben

Ben

Hi, my name is Ben, I am a seventh grader, and this is my first year participating in FTC. Before I joined the team, I had done other forms of robotics. I enjoy working on cars and trucks with my grandfather.

Mason

Mason

Hi, my name is Mason, I am a seventh grader, and this is my first year doing FTC. I've always been interested in robotics and building things, so when I heard that there was a team in East Troy, I just had to join. In school, I take advanced math classes.

Meet Our Team Members and Mentors!

Joey

Joey

Hi, my name is Joey, and I am a freshman. I am on my second year doing robotics. I think that robotics is a ton of fun, and I especially enjoy driving the robot. My other interests include driving RC cars and trucks and playing video games.

Mr. Griffin (Mentor)

Mr. Tim Griffin (Mentor)

Hi my name is Tim, and I am a Tinker & geek. I enjoy wood and metal working, building and designing µ-processor projects, gardening and cooking. I am a member of the local computer club and am on an advisory committee trying to implement a makerspace at our local library. I am also passionate about guiding and inspiring the latest generation to become producers, not simply consumers.

Engineering Notebook Engineering Section

Meeting Date: 9-16-2015

Meeting Time: 5:30-8 pm

Tasks:	**Reflections:**
Assemble one mountain for the field structure.	We finished one mountain and proceeded to brainstorm ideas for getting up it.

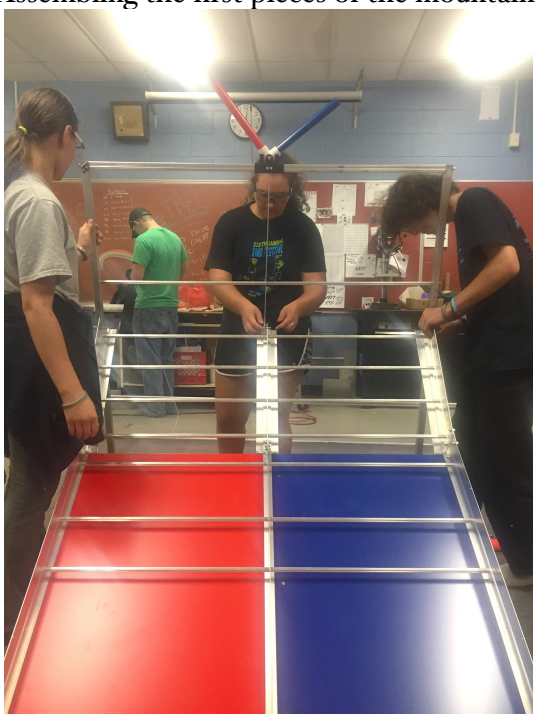
Field Structure

Because of space limitations, we decided to only assemble one of the mountains for the field. Once we got the whole thing together and could see what we would have to conquer to "climb" the mountain, we started to brainstorm ideas. Some of the ideas we came up with were using tank treads with grippers to climb the mountain, using hooks to hook onto the bar and pull ourselves up the mountain, and having skis on our robot so we can pull ourselves up the mountain. Because the bars are so high, we figured we might have a climbing advantage if we used an upside-down triangle shaped tank tread, with three sprockets, the middle one lower than the other two. This would keep us from sliding down the mountain when we get over a new rung. We noticed that the bins get in the way if you are the full 18" so we think that we are going to have a longer, rectangular robot. We can get more length if we fit diagonally in the sizing cube. We are thinking about using a pulley system that extends out from the bottom of our robot to pull up on the bar.

We prioritized what we want to accomplish with our robot in the following order:

1. Climb mountain (base design)
2. Hang from pull-up bar
3. Tip signal indicator
4. Release climbers on our way up
5. Everything else

Assembling the first pieces of the mountain.



Finishing assembling the mountain.

Meeting Date: 9-23-2015

Meeting Time: 5:30-8 pm

Tasks:	**Reflections:**
Brainstorm ideas for the wheel base.	We decided to prototype the 4 wheel drop-tank and the standard tank with nubs.

Base

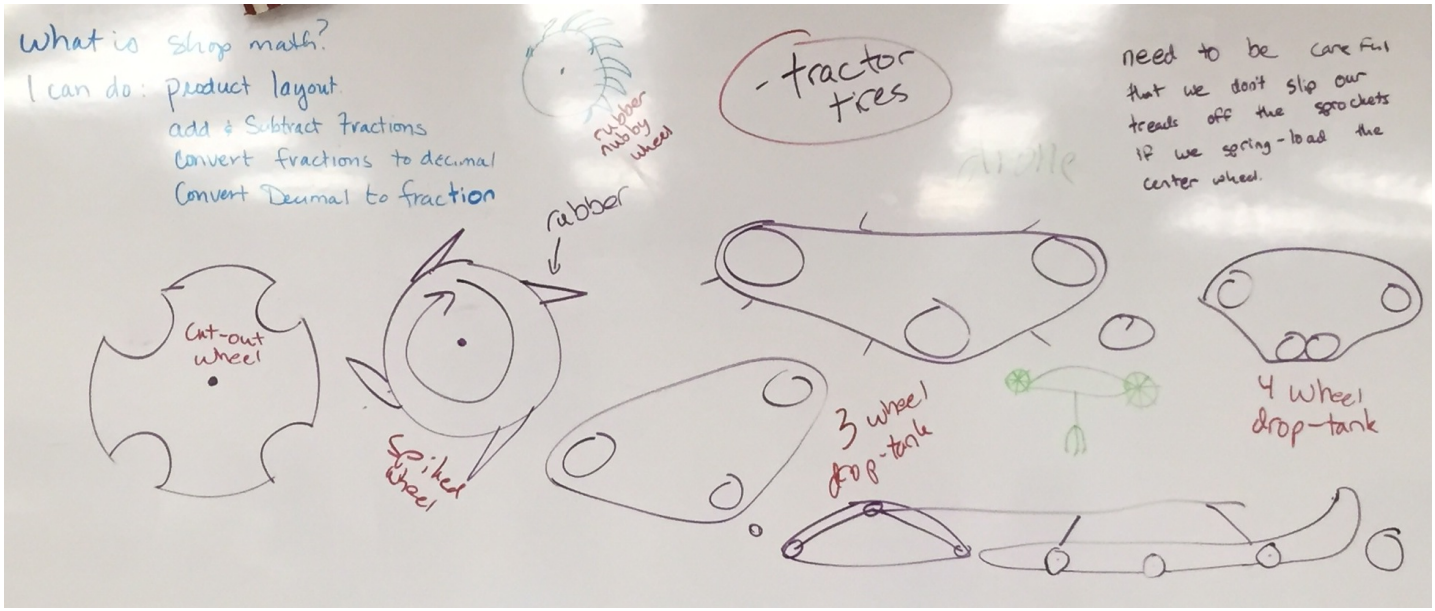
We prioritized climbing the mountain as our first priority, so we came up with several different base design that would allow us to climb the mountain. We drew a sketch of each one, and then made a list of pros and cons for each idea we came up with. We decided to prototype the standard tank base with nubs on the tracks, and the 4 wheeled tank design with two wheels in the middle lower than the others (drop tank).

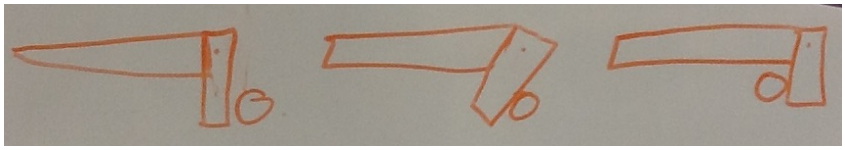
Piece	Pros	Cons
Standard Tank with Nubs	Durable, high-traction, won't get stuck on the churros, all-terrain, nubs will grip onto churros (won't slip), can go up and down mountain with ease	Harder to stear, low battery efficency, bulky, might tear up field surface, might be difficult to obtain, can be expensive, can jam or slip off sprockets
3 Wheel Drop-Tank	Durable, high-traction, won't get stuck on the churros, all-terrain, nubs will grip onto churros (won't slip), can go up and down mountain with ease, dropped wheel will let us get over churros more easily and accomidate angle change, continuous forward or backward motion	Harder to stear, low battery efficency, bulky, might tear up field surface, might be difficult to obtain, can be expensive, can jam or slip off sprockets, tippy, questionable performance on field
4 Wheel Drop-Tank	Durable, high-traction, more efficient than standard tank. won't get stuck on the churros, all-terrain, nubs will grip onto churros (won't slip), can go up and down mountain with ease, dropped wheel will let us get over churros more easily and accomidate angle change, continuous forward or backward motion, more steady than a 3 wheel drop tank	Harder to stear, low battery efficency, bulky, might tear up field surface, might be difficult to obtain, can be expensive, can jam or slip off sprockets, tippy, questionable performance on field, heavier
Air Drone	Extremely manuverable, can go anywhere, we don't have to worry about climbing the mountain, can hover, awsome factor, can avoid collisions with other robots (don't have to share floor space)	HARD, HARD, HARD, super expensive, must be very light-weight, programming and flying it, ballance, difficult design, time-consuming (would have to sacrifice other pieces)
Skis with Wheel Assist	Will slide over churros, fast, won't damage floor, easier to fit into 18" cube, can be small and lightweight	Stearing, dealing with angle changes on mountain, other robots and field elements can get caught in the skis, wheel assist can slip on the churros (not as grippy as a tank tread)
Wheels with Cut-Outs	Lighter, less bulky, fairly easy to make, cheap	If circles are too big they can get stuck on the churros, if cut-outs aren't positioned right the wheels might not clip onto churros, wheels don't have a great grip aside from the cut-outs, won't work when we get to the section with high section of the mountain
Spiked Wheels	Lots of grip, can handle the churros, easy to drive, not bulky, will hook onto churros, cheap	Clips only go one way so we might have trouble going down, might tear up field, unsure how it will handle the angle change on mountain, can get stuck between the churros, won't have anything to rest on when we get to the high section of the mountain

Meeting Date: 9-23-2015

Meeting Time: 5:30-8 pm

Wheels with Rubber Nubs	Lots of grip, can handle the churros, easy to drive, not bulky, will hook onto churros, cheap	Might tear up field, unsure how it will handle the angle change on mountain, can get stuck between the churros, won't have anything to rest on when we get to the high section of the mountain
Hook Arms	Great grip on churros	How are we going to move the base when we are on the floor (only works on churros), will need two sets (one for up and one for down), doesn't handle angle change well (will need several other mechanisms to assist with this)
Tractor Tires	Easilly obtained, good stearing, are soft so they will be able to get over the churros	Won't do well when we are on the high section of the mountain with no floor, bulky





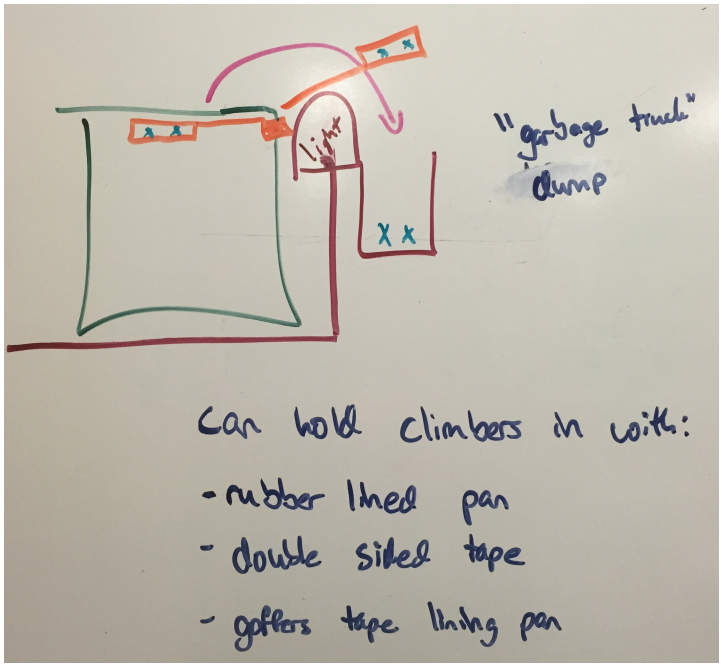
Meeting Date: 9-26-2015

Meeting Time: 9am-12pm

Tasks:	**Reflections:**
Assemble the zip line and beacon repair station.	We finished assembling the zip line and beacon repair station.
Brainstorm ideas on how to dump the climbers into the shelter.	We decided to use a "garbage truck" style dumper to get the climbers into the shelter.
Brainstorm ideas on how to hang from bar.	We decided to use a pulley system that will be raised by a lead screw for our hanging mechanism.
Test different methods for pushing the beacon repair button.	We found out that using a flat plate would work the best to push the button.

Climber Dumper

We decided that we wanted something really simple to get the climbers into the shelter. Using a mechanism that looks something like the dumper on a garbage truck will allow us to use only one motion to get the climbers into the shelter. There will be a tray that holds the climbers, and it will be attached to a servo that will allow us to rotate it 180 degrees and dump them directly into the shelter. We are going to mount it at the very top of the 18" cube, so we won't have to raise anything to get over the beacon repair station. To keep the climbers in place during the flip, we came up with several ideas, including taping them on, putting a rubber grip bottom in the tray, and making a formed plastic mold for them to sit in. We decided on the formed plastic mold because it will conform to the shape of the climbers and not let them slip around until they are completely flipped over.



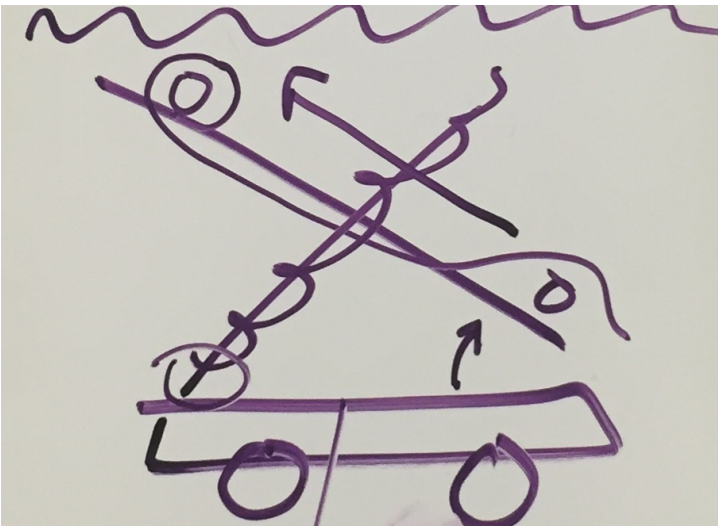
Our idea for dumping the climbers.

Hanger

There was strategizing about what we would be attempting this year and judging what would be the best use of our resources and the limited time of the match. We decided that one of our top priorities is to attempt the hang, and began thinking of ways that we could accomplish this. We decided that our

Meeting Date: 9-26-2015

Meeting Time: 9am-12pm



Our lead screw and pulley system idea. The robot is viewed from the right side, with the front facing towards the right of the photo.

Hanger (continued)

hanging mechanism would work best if it was mounted in the middle of our robot, as flat as possible to maintain a low center of gravity while climbing the mountain, and then raised up to the angle that we will need to grab the top bar on the mountain. For pulling ourselves up on the bar, we are going to use a hook mounted on a series of extending rails that are extended and retracted by a pulley system. To raise this system off of the bed of the robot, we are going to use a lead screw that will push the pulley arm, with the hook towards the back of the robot in the lowered position, up so that the hook is resting just above the bar, and the pulley system will then retract the arm so that our robot is raised until completely suspended.

Button Stompers

We tested several methods for pushing the button on the beacon repair station, including rolling a wheel across it, poking it with a finger-like rod, and pressing a flat plate over the general area. We decided that a flat plate that is extended out by a servo to "stomp" on the button would be the easiest method to press the button because of its simple design and large allowance for error. To sense the color of the beacon, we will have one color sensor pointed at one of the sided of the beacon. If that is our color, we will push that button, if not, we will push the other one. We will have two button stompers, on for each side of the beacon repair station.

Flippers

To trigger the mechanism that releases the climbers down the zip line, we will need two flippers that we can extend out on a servo, one on each side of the robot, because the plastic tripping mechanism will be on different sides of our robot depending on which alliance color we are.

Meeting Date: 9-30-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Prototype 4 point tank tread design for base.	We created a basic square base out of channel and used sprockets and plastic chain to mimic our tank tread design.

<u>Base</u>

Prototyped base and tank treads by creating a basic square for the base. We then attached the mock tank treads: sprockets and plastic chain that we had on hand. We used four point military style treads in order to get over the churros and mountain high zone without falling between the churros and getting stuck.

Our prototype.

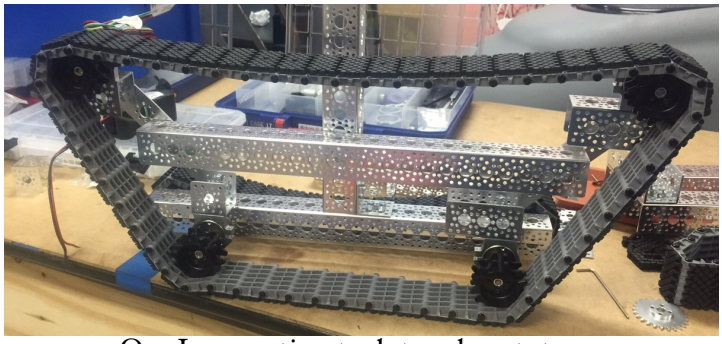
Meeting Date: 10-3-2015

Meeting Time: 9am-12pm

Tasks:	**Reflections:**
Prototype tank drive for base.	We used Lynxmotion tank treads to prototype the four-point tank tread design.

Base

We used Lynxmotion tank treads to create an oversized version of the four-point tank tread design to be used on the bot. They worked great, and they had extraordinary gripping power on the mountain. They need more support to eliminate the wobble in the treads while in motion. We might use polycarbonate sheets for support, or machine an aluminum housing.



Our Lynxmotion tank tread prototype.

Meeting Date: 10-7-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Finish tank tread prototype and test it.	We completed the tank tread prototype, and we noted that it was top-heavy when we tested it.
Assemble the blue beacon repair station and shelter.	We finished the blue beacon repair station and shelter.
Brainstorm how to release the climbers on the zip line.	We discussed how we might go about flipping the triggers to release the climbers.

Base

We finished the four point tank tread prototype and tested it on the mountain. We noted top-heaviness, and added weight to the bottom of the base to lower the center of balance. We also noted that the treads are currently over-sized, causing much of the top-heaviness. To be fixed next meeting.

Flippers

Some of our ideas on how to flip the climbers included using a bar or arm that would extend from the side of the robot to hit the triggers. We are going to do more brainstorming in the future.

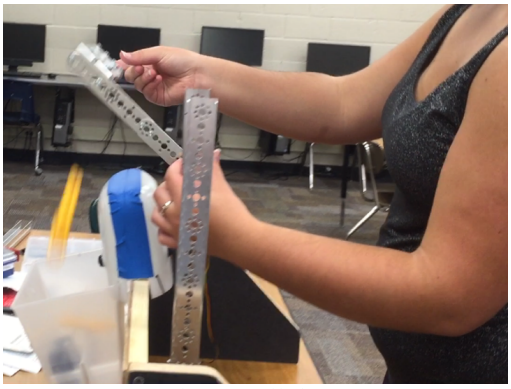
Meeting Date: 10-14-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Downsize treads to fit within 18" cube.	We scaled the treads to fit 18" size specifications and tested tread grip.
Prototype the climber dumper design we came up with during brainstorming.	We are going to use a dumper that holds the climbers parallel to the bucket.

Base

We downsized our tank treads to fit 18" cube specifications and to reduce the top heaviness of our robot, and angled them at ~40 degrees. We encountered an assembly snag in one of the sprockets, where it was not turning. We figured out what the problem was, and it will be easy fix at the next practice.



Testing the parallel prototype.

Testing the perpendicular prototype.

Climber Dumper

We prototyped the garbage-truck style climber dumper with two variations. One of them held the climbers parallel to the shelter, and the other one held them perpendicular to the shelter when they were placed in the robot. We used a standard 180 degree servo with an arm attached to it, and attached the climber tray to that arm. We made our prototype trays interchangeable so that we could test both (the parallel and the perpendicular). After testing, we observed that the perpendicular tray had a tendency to miss the shelter, and the parallel tray consistently got the climbers into the shelter. For this reason, we decided that our proof of concept and final design will use the parallel tray design.

Meeting Date: 10-17-2015

Meeting Time: 9am-12pm

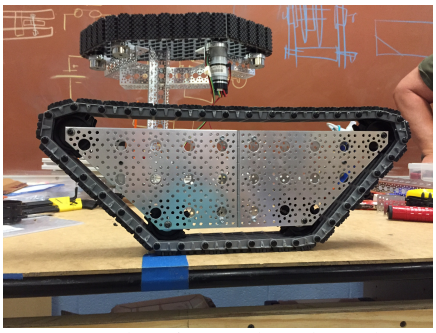
Tasks:	**Reflections:**
Create a proof of concept for the climber dumper.	We used Insta-Morph plastic and aluminum bar stock to create a new version of our prototype, and we successfully tested it.
Build treads based off prototype.	We assembled one side tread using Actobotics 4x12 inch plates and the lynx-motion treads.

Climber Dumper

We wanted to make our final design lighter than the aluminum prototype that we had created, so we used Insta-Morph plastic (plastic pellets that you put in hot water and are then able to shape into whatever you want) to create a custom tray for the climbers. We bolted that onto a long piece of aluminum bar, which is strong yet lightweight. We attached the servo horn onto the other end of the bar. Because the bar only had a single series of holes drilled down it, there was no preexisting hole for the screw that the servo horn is held on by, so we drilled a hole for that screw. We drilled it as big as the head of the screw because the screw wasn't long enough otherwise. We tested out our proof of concept, and it works as expected. We are going to swap out the standard servo that we have been using for a quarter scale servo so that we have enough power to raise the tray.

Testing the climber dumper.

The new climber dumper design.



One side of completed tracks.

Base

Drilled out holes for lynx-motion bearings in 4x12 inch actobotics plates and mounted the tread sprockets. We needed to cut the plates at an angle between the top and bottom treads to allow the tread through. Also noted that the screws holding the bearings to the sprocket axel can come loose during operation of the tread. We will lock-tite the screws in next meeting to avoid this.

Meeting Date: 10-21-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Complete a second set of tank treads.	We completed half of a second set of tanks, due to lack of parts.

Base

Built half of the second set of tank treads using the lynx-motion treads. lacking parts to complete the second half. To be completed next meeting. Began brainstorming methods of attaching drive motor to the treads using a motor mount and no small amount of creativity.

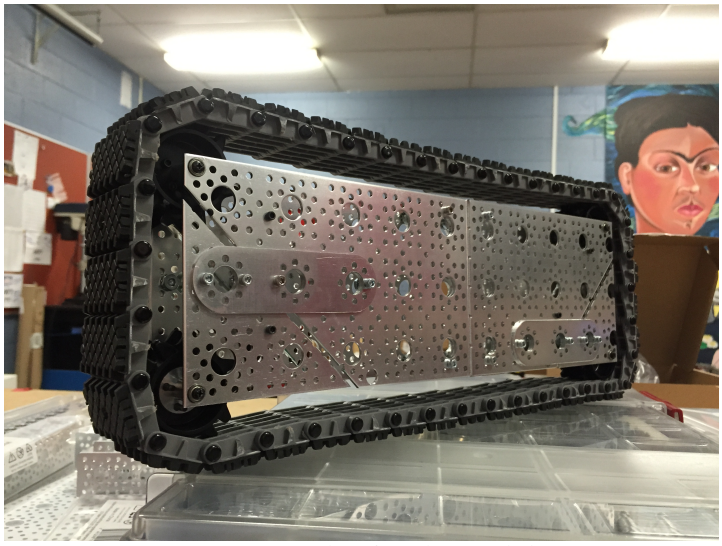
Meeting Date: 11-7-2015

Meeting Time: 9am-12pm

Tasks:	**Reflections:**
Finish tank treads (new rectangular design).	Converted treads to be rectangular and slightly shortened the tread frame to accommodate tread length.
Determine how to mount motors.	We mounted the motors to the base plate and attached them to the tread drive sprockets.

Base

We reconfigured the tread frames to have a rectangular shape and slightly shortened the frame to accommodate the tread length, then added a plate between the two treads as a central mounting point. Our new design for the tank treads is a squared off end on both ends so that we have a larger base for more stability. There was too much slop in the treads before, so we moved one set of sprockets back one half inch, and that took the slop out of the treads. We used a large flat aluminum plate from Servo City to make our building base for the robot. It is attached to the inside of the tank treads with two L brackets on both sides. We tested it for stability on the mountain, and it looks good. It will rest on the last churro of the mid zone when we are in the high zone, giving us enough stability to raise our hanging mechanism and hang our robot. We began testing various options for mounting the motors, more to be done next meeting. May need to make a custom bracket if all else fails. For now, we mounted the motors to the bottom of the main base plate, parallel to the treads. Mounted the rear bottom corner tread sprockets on each side of the treads on an axle. Connected the motor to the axle using bevel gears at a 1:1 speed ratio. Will add extra support for the axles next meet.



Our new, squared-off tank tread design.

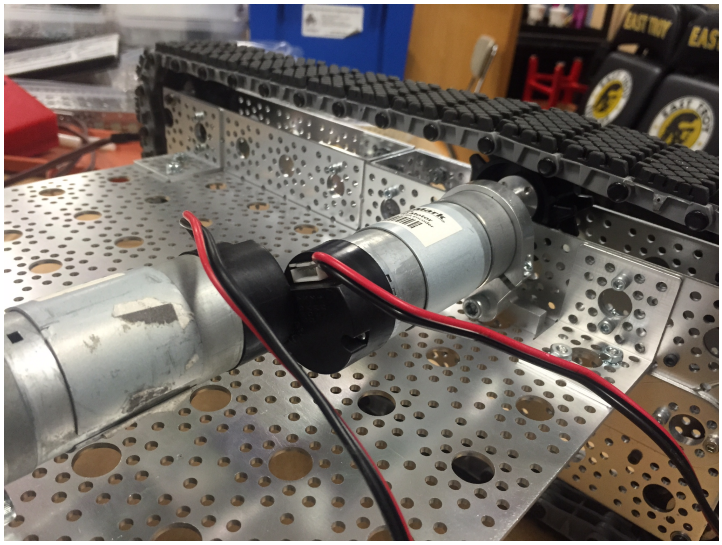
Meeting Date: 11-14-2015

Meeting Time: 9am-12pm

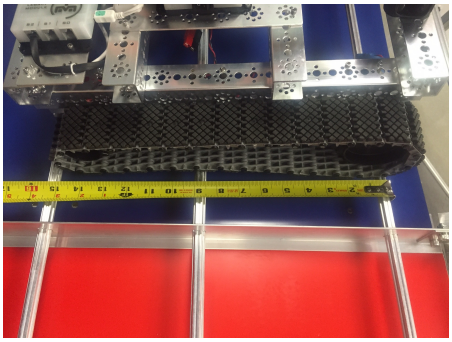
Tasks:	**Reflections:**
Determine motor mounting options.	We used beveled gears to mount the motors to the front bottom sprockets on the treads.
Find how long the tank treads must be to avoid getting stuck.	Our trials showed that the treads should be 17 inches long to avoid getting stuck between churros.

Base

We first tried mounting the motors on sprockets that we had inserted on the bottom side of our tank treads, roughly in the middle of the bot. On the flat, this worked just fine, but when we tried to climb the mountain the treads started to slip off the sprockets. We realized that we would have to mount to one of the four sprockets we already had on either side. We chose the bottom front sprockets. We mounted the motors to the bottom of the main base plate, parallel to the treads. Mounted the rear bottom corner tread sprockets on each side of the treads on an axle. Connected the motor to the axle using bevel gears at a 1:1 speed ratio. Will add extra support for the axles next meet.



Our first attempt at mounting the motors.



Determining the length the treads needed to be.

Test Bot

Today, we decided to see how long the treads would need to be in order to reduce the likelihood of the tank treads getting stuck in between churros. We started up and had the testing robot, which we have named "Minion", hooked up and ready to drive. We made several attempts, none of which succeeded completely. We decided that the tracks would need to be approximately 17" long so that Minion wouldn't get stuck.

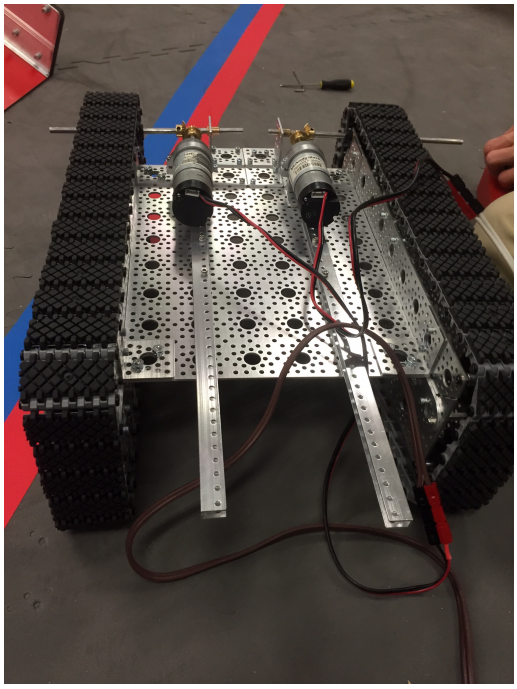
Meeting Date: 11-18-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Complete and test the bevel gear drive system.	We completed and tested the bevel gear drive system, noting several slippage problems, and began building a chain drive system.

Base

We finished assembling and testing the bevel gear drive system. We stabilized the drive axles with L brackets that we ran the axles through the holes with bronze bushings. The gears were slipping so bad when we went backwards that we couldn't use that drive system. We tried putting a shim under the motors to stop the gears from slipping, but that didn't work either. Despite extra support, the gears slipped a lot, especially turning, and had a tendency to come loose from the shaft. We then decided to try a chain drive system. The motors are perpendicular to the tracks, and one is closer to the front than the other so that there is room (the motors were too long to mount in a straight line). When we were testing the robot, we observed that it went up the mountain better when the non-powered sprockets went first and the powered sprockets went second.



The beveled gear drive system.

Meeting Date: 11-23-2015

Meeting Time: 3-5pm

Tasks:	**Reflections:**
Swap tank tread sprockets out for larger sprockets.	We swapped out the lower front set of sprockets for a larger size.

Base

We had been playing around with a larger size sprocket on our test robot, and they seemed to be going up the ramp better, so we decided to try them on our actual robot. We swapped out the front set of sprockets on the lower half of the tracks (the ones that touch the floor, the ramp, and the ones that hit the churros) because those are the ones that we lead with when we go up the ramp.

Meeting Date: 11-25-2015

Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Swap tank tread sprockets out for larger sprockets.	We swapped out the lower rear set of sprockets for a larger size.

Base

After swapping out our front set of sprockets for a larger size, we decided that we should swap out the lower rear set as well, in case we wanted to go up the ramp backwards. It should also make backing down the ramp easier if we choose to do that.

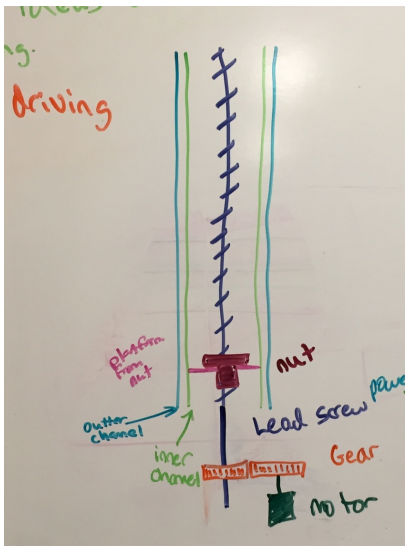
Meeting Date: 12-2-2015

Meeting Time:

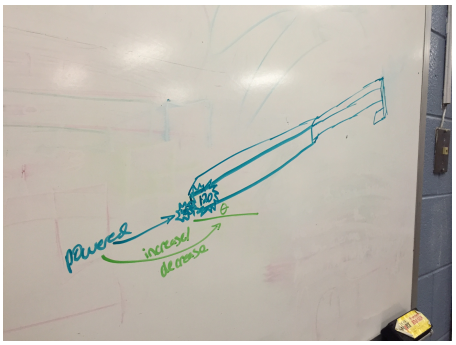
Tasks:	**Reflections:**
Come up with preliminary ideas on how to hang.	We thought about using a pulley system, a lead screw, or nesting channels.
Trouble-shoot problems with the communication system and motor controllers on our test robot.	We reattached all of the modules and taped the connection, but we didn't find any concrete solution to our problems.

Hanger

We started to brainstorm some ideas on how we could hang our robot. We sketched some preliminary ideas, including using a pulley system or a lead screw to extend a series of nested channels. We found inspiration in a design that used linear bearings on the outside of the channels to create a linear slide. We also thought about nesting two different sized channels inside one another. We didn't create any physical prototypes with these ideas at this meeting.



A sketch of our lead screw idea.



A sketch of our pulley system idea.

Test Robot

Once we drove the robot there were many connection problems, we tried to get Minion driving strait mechanically by elevating the back end of the robot so it will be more level as it climbs the ramp. To fix the problems with the electronics and communications, we plunged and unplugged the the USB drives. After that it still did not work so we taped the USB drives.

Meeting Date: 12-5-2015

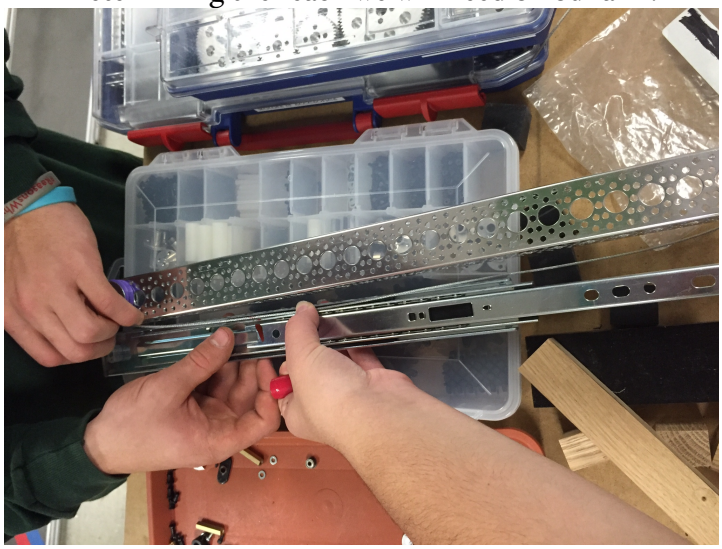
Meeting Time: 9am-12pm

Tasks:	**Reflections:**
Brainstorm ideas on how to hang the robot.	We are going to prototype a hanger that delivers a hook to the top of the mountain and then uses a winch to raise the robot.

Hanger

Some ideas that we came up with for hanging the robot were an arm that is extended/retracted with a lead screw, a series of channels that are connected by linear bearings and extended by a pulley system, and using a winch with a hook. After looking at all of the different ideas, we decided to go with the winch and hook idea because the lead screw was going to have a hard time reaching far enough and the linear bearing/channel set-up was going to be hard to make go up and down to hook onto the bar and then pull the bot up. The hook in our design will be raised be an arm and placed over the top bar of the mountain. The hook will consist of a long piece of channel that is attached to a piece of steel cable. The steel cable will be attached to the winch, which will be used to raise the robot. The winch and arm being separate is an advantage to us because it means that the arm doesn't have to be very sturdy, and it only has to go one way. We are going to mount the arm at an angle, with the pivot point in the back of the robot, because that maximizes the length of the arm we can build, so we don't need as many pieces to extend. With the size of our robot, we can use a 20" or 22" drawer slide (compressed size, extension doubles the measurement), which is just enough to reach the top bar of the mountain. From where our robot can drive on the mountain (just into the high zone), we need about 40" of reach to attach to the bar. To extend the drawer slide, we are going to attach a piece of steel cable to it at the bottom of the last slide-out. The steel cable will be a continuous loop around two pulleys, one of which is powered by a motor, and when the motor turns, it will rotate the cable, which will in turn extend the drawer slide.

Determining the reach we will need on our arm.



Working on a design that will allow a pulley to extend a drawer slide arm.

Meeting Date: 12-9-2015

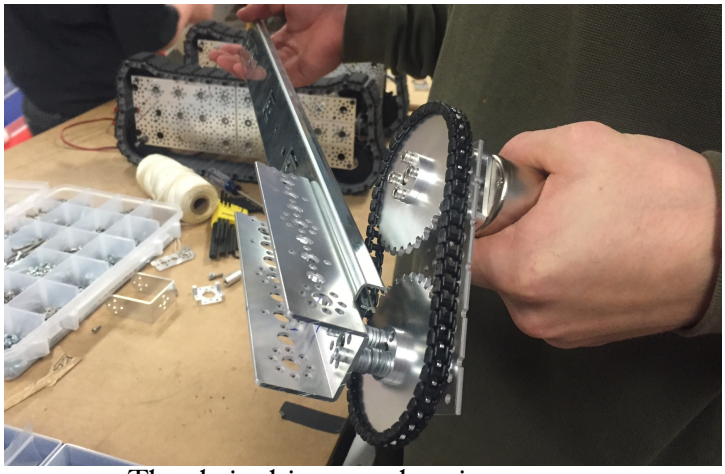
Meeting Time: 5:30-8pm

Tasks:	**Reflections:**
Build a prototype of the hanger extension system using a drawer slide.	We built and tested methods of attaching the drawer slide to the robot.
Prototype a winch to retract grappling hook.	We made a prototype winch that will help the robot op to hang on the bar.

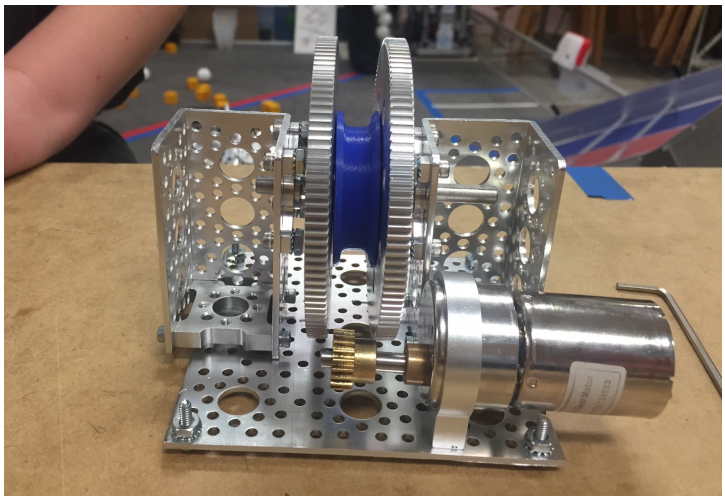
Hanger

We designed a prototype for attaching the drawer slide to the main base of the robot using pre-existing holes in the slide that lined up with a tetrix piece. We bolted a chain sprocket to the plate, a bearing to the sprocket, and an actobotics plate to the bearing. We then mounted a motor with a chain sprocket on the actobotics plate and connected the two sprockets with a chain. We discovered that in the course of turning, the bearing could come loose, however, and began replacing the bearing with a shaft, which we will finish next meet. We will also test whether we need to reduce the gear ratio, and whether a servo can rotate enough to function in place of a motor.

We took two gears and a homemade bearing to make the cord attached to the grappling hook retract. We will have to mount the winch to the bot when it is finished, but for now, we put together a prototype that will need some minor changes. We also sat and thought about how we are going to make the winch and where we are going to mount it



The chain drive arm elevation system.



The winch prototype.

Meeting Date: 12-12-2015

Meeting Time: 9am-12pm

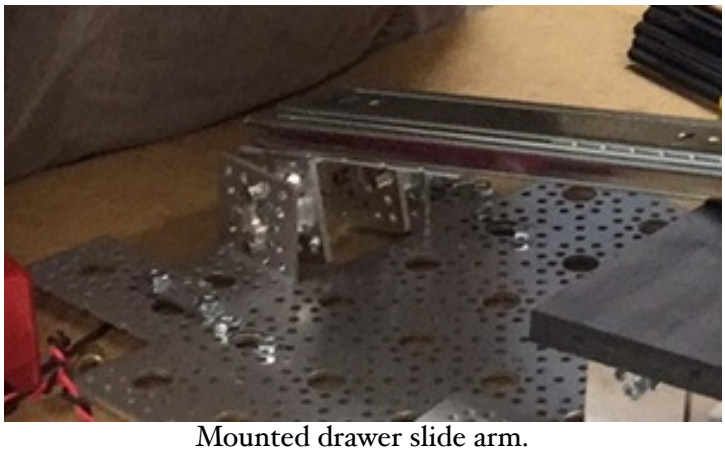
Tasks:	**Reflections:**
Prototype hook delivery arm elevation mechanism.	We are going to use a small lead screw and a worm gear to change the angle of elevation of the arm.
Prototype methods of attaching the hanger mechanism to the main base.	Attached hanger to base and experimented with movement options.
Finish and test a prototype the winch.	We tested the winch and found it successful.

Hanger

To change the angle of elevation of the hook delivery arm, we are going to use a lead screw. The arm and the lead screw will both have pivot point where they attach to the base of the robot so that there is no pinching when the arm is raised or lowered. To ensure that there is enough power for the lead screw, we are going to use a worm gear attached to the motor. We are mounting the motor and worm gear using Tetrix parts. We started mounting the pieces with the worm gear in channel and the motor mount attached to a larger base plate. To get the motor closer to the worm gear channel, we cut a bronze bushing down so that it is shorter, and we drilled out one of the worm gears so that the motor shaft can to all the way through. We also had to drill out the other worm gear to 1/4" because we need to attach it to the lead screw's shaft.

We used the holes in the drawer slide to attach it to a couple L-brackets, which bolted to two bearings. The bearings were then bolted to the main base via two more L-brackets. Noted that the drawer slide is on the heavy side, and needs to be geared down for more controllable movement and so the motor can hold it in place.

We tested the winch mechanism, which proved plenty powerful. We were able to pull a team member with it!



Mounted drawer slide arm.

Testing the strength of the winch.

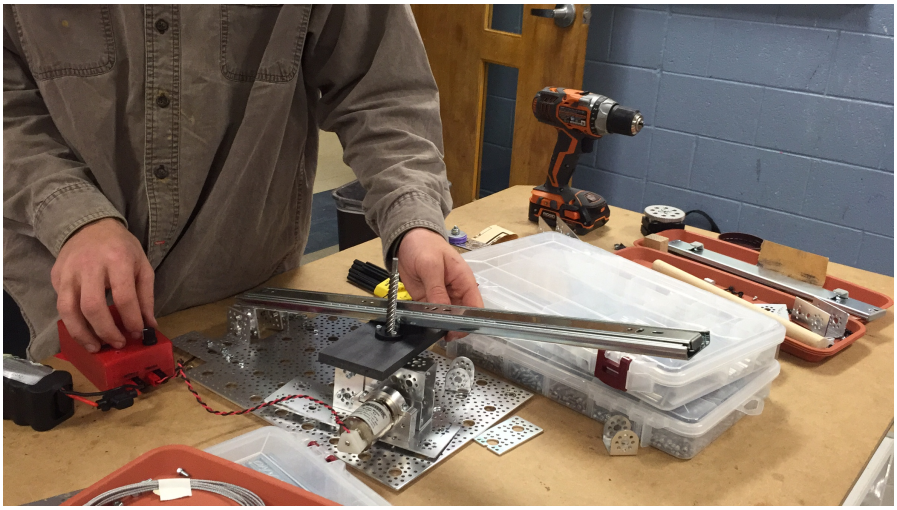
Meeting Date: 12-16-2015

Meeting Time: 5:3--8pm

Tasks:	**Reflections:**
Test the lead screw design for elevating the hook delivery arm.	The lead screw was the perfect speed and power, but we figured out that we are going to need to add a pivot on the bottom of the lead screw.
Design a mechanism to extend the hook delivery arm.	We started to build the drawer slide extender.

Hanger

We attached the motor and worm gear housing channel to the base plate that we are using and added both worm gears. We had to put a flat on both turned-down ends of the lead screw so that we could secure the set-screws. We are going to put the nut for the lead screw on a flat bracket that extends to one side of the drawer slide and is secured underneath the drawer slide. We attached the lead screw to the base and used it to lift the drawer slide using a piece of string. However, the plate tied to the string caught on the screw mechanism. We then simply used a plate on the screw mechanism to lift under the drawer slide, which worked much better. A bar on the opposite side of the drawer slide will keep the plate on the screw from turning. When we went to test the lead screw, we realized that we will need to put a pivot point on it, and after exploring our options, we decided that it would only work if we put the point at the bottom of the lead screw.



Testing the lead screw elevation mechanism.