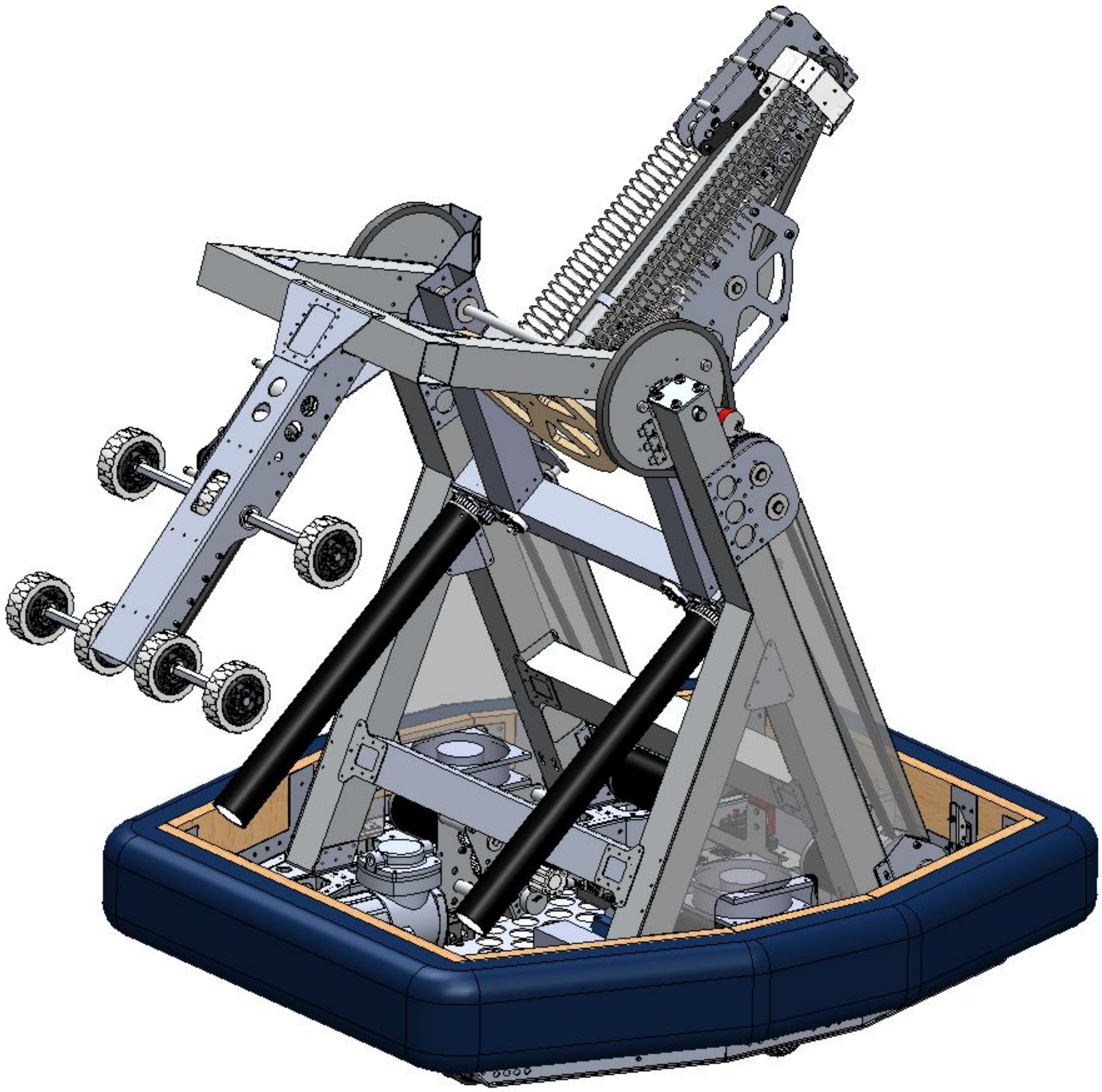
# Spartan Robotics



## 2014 Technical Document

# Spartan Robotics’ Design Objectives

On Spartan Robotics, we believe that engineering is the process of optimizing a solution to perform its task as efficiently as the laws of physics allow. Our goal is to develop the highest quality robot possible and relentlessly chase perfection.

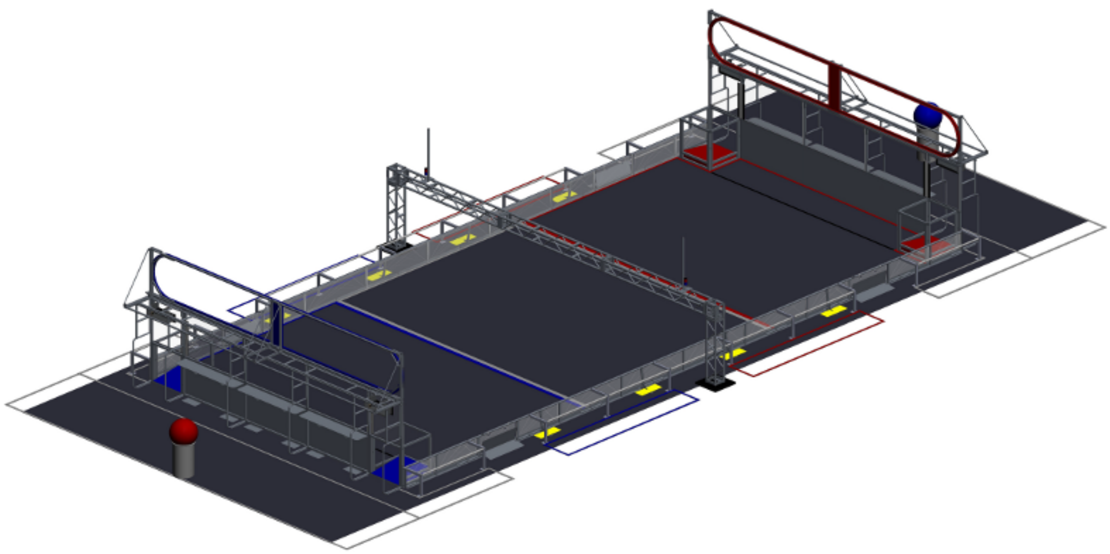
## Design Process

1. Identify necessary functions.
2. Determine assemblies, allocate the desired functions to different assemblies.
3. Prototype each subassembly.
    a. Use CAD to determine feasible geometries and hands on prototyping to confirm these geometries.
4. CAD is to make designs and drawings for manufacturing and eventually assembly.
5. Coding then integrates the subsystems and uses state feedback control to make the robot run reliably and consistently.

# Aerial Assist

This year's game is played with a 4 foot diameter ball. The match begins with autonomous period where each robot has 10 seconds to score their autonomous balls without the use of human operators.

During teleoperation, alliances can pass a ball between their robots and over a truss, and then score the ball in either the high goal or the low goal. Each pass to another robot and each goal shot into the high goal is worth 10 points. A pass over the truss and catching the truss shot also each receive 10 points.



# Game Strategy/Design Requirements

- Assisting is key for qualification matches
- No protected zone
    - Going to be a very physical game so robot needs to withstand collisions
- Needs to score rapidly
- Needs to be able to easily pick up the ball
- Needs multiple ball autonomous
- Needs to be versatile enough to perform various plays

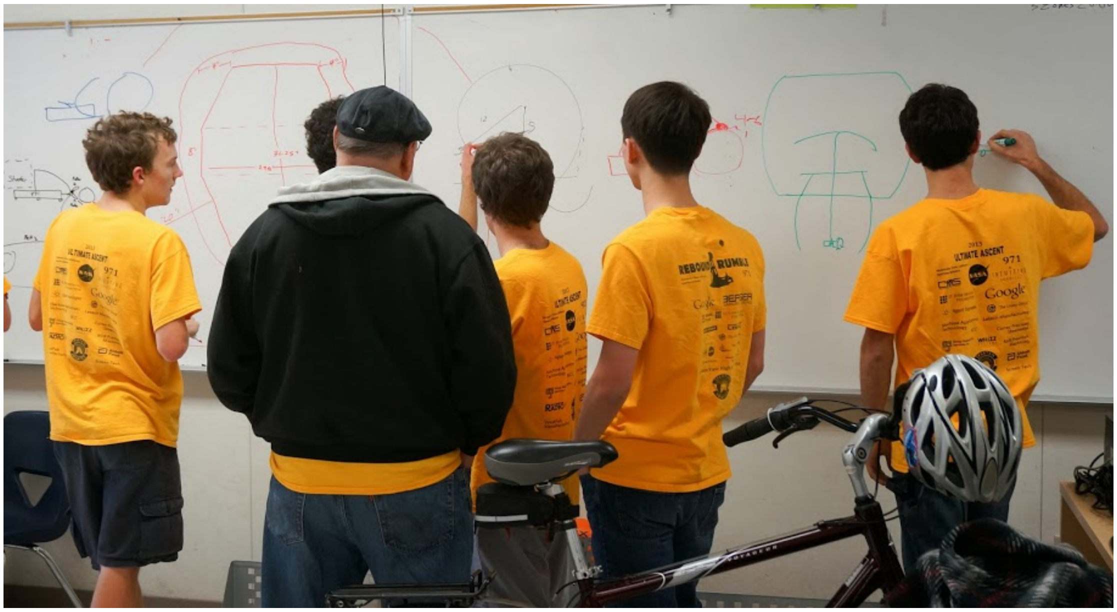
# Drivetrain

Our current drivetrain is a culmination of several iterations over the past three years. In 2012, we deviated from the theoretically “perfect” six wheel dropped center West Coast Drive drivetrain in search of an even better design against defense.

In doing so, we produced a drivetrain that is better than the standard West Coast Drive and and believe that this will give us a maneuvering advantage over other teams.

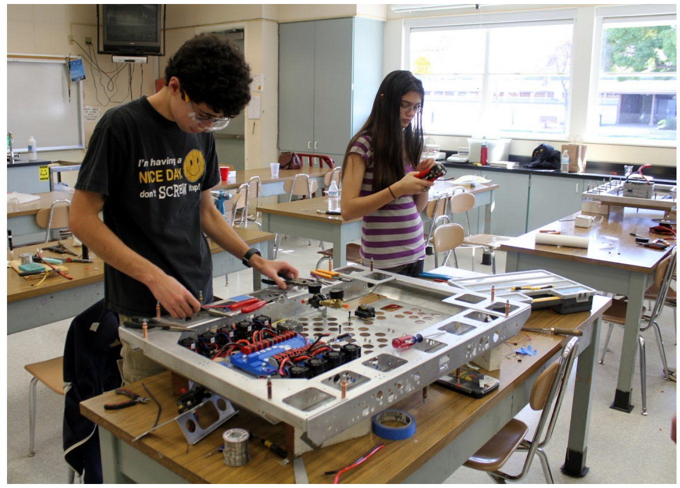
## Required Functions:

- Light weight
- Low center of gravity
- Allows drivers to maneuver well
- Easy to maintain

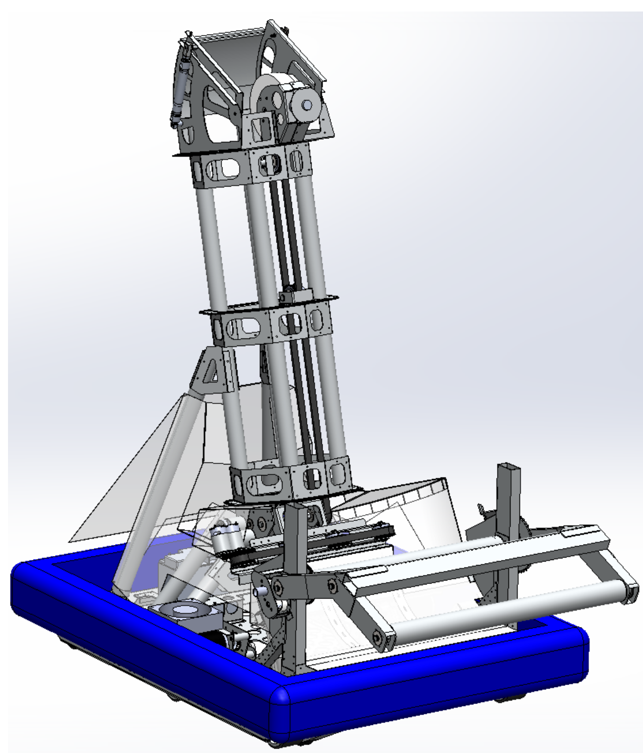


# 2012 Drivetrain

- **Initial Design**
  - Clamshells that fit into a wrap around bellypan
    - Provides torsional support with minimal weight
  - CIM located above the wheels
  - Second transmission reduction on wheel
  - Wheels use zip ties for easy replacement
  - Timing belts on dead axle wheels
    - allows wheels to drop out the bottom of the base for replacement

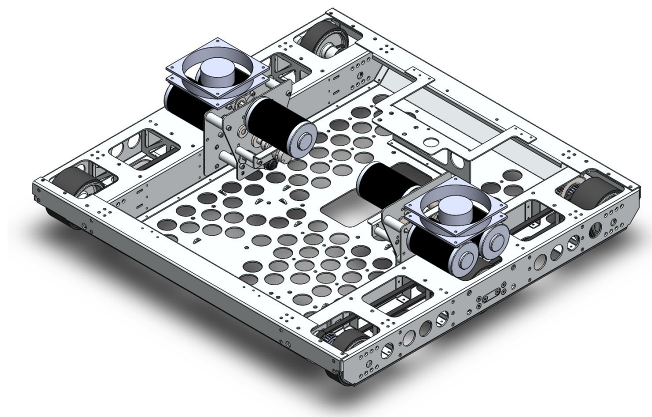


- **Issues**
  - Tensioners
    - push tensioner hard to use
    - welding caused them to warp
  - Two inch wheels made turning difficult
  - Encoder location unprotected

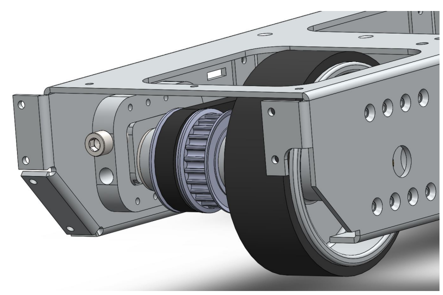


# 2013 Drivetrain

- **Fixes**
  - Outside wheel were 1” wide and with smaller wheelbase provided better turning
  - Two sided tensioners eliminated need to weld
    - designed pull tensioners that are easier to maintain
  - Moved encoder onto the transmission dog shaft



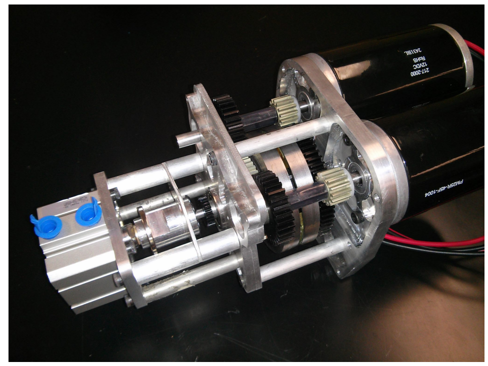
- **Issues**
  - 3 CIM transmission tripped breaker
  - Easily pinned by defense
  - Slow to shift into different gears - increased potential to lose in defensive battles



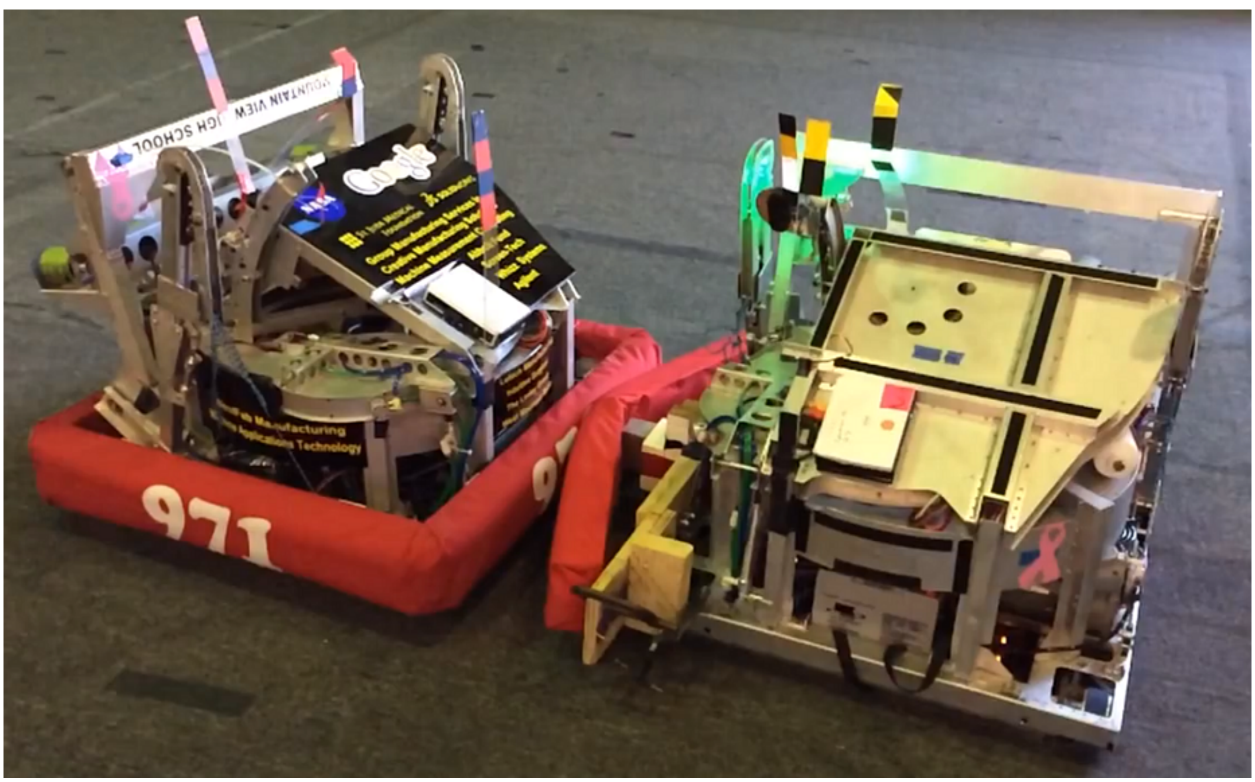
# 2013 Offseason DriveTrain Testing

After the 2012 season, it was decided to spend time investigating possible innovations in our drive train design.  Two areas of study were the feasibility of an automatic clutch transmission and whether different base design choices could help reduce defensive pinning during a match.

- Tested octagonal base and bumper material at NASA Ames
- Designed and built clutch transmission and successfully ran at the Madtown Throwdown offseason event



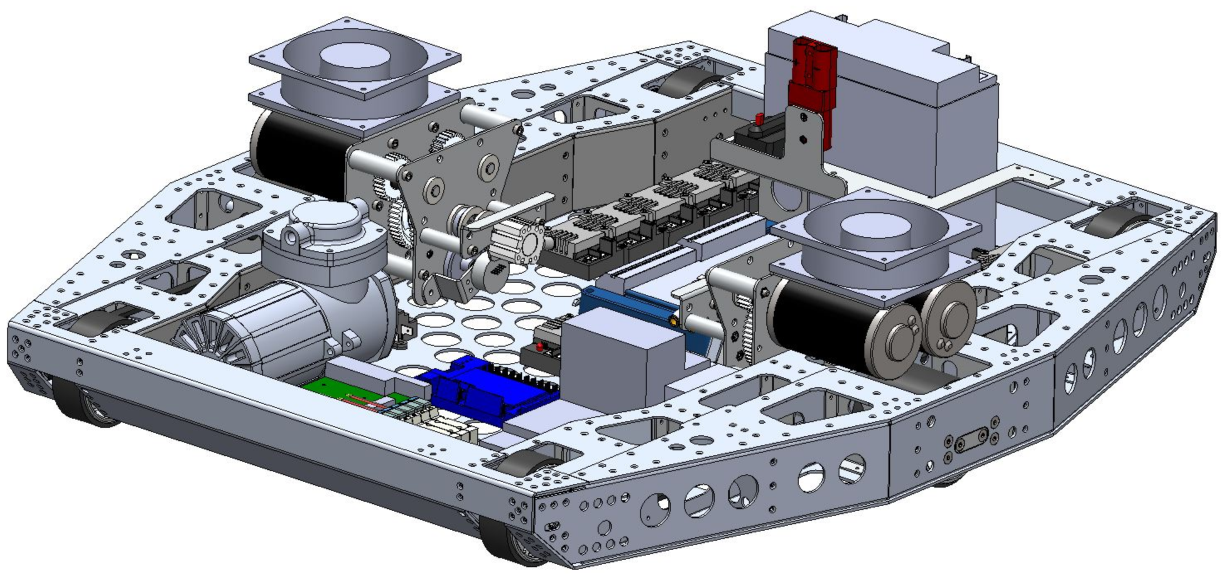
**Clutch transmission**




**Bumper testing**

# 2014 Drivetrain

As a result of these two off season projects, it was decided to modify the base and bumper design. While the clutch transmission was shown to be effective, the performance improvement was not enough to justify the amount of machining necessary to implement the design during a competition season. During testing, it was determined that the current transmission design could be made to be as effective using sensors and code.



# Fixes

- Octagonal shape and Ballistic Nylon bumpers help prevent pinning
    - Offseason testing determined that octagonal shape allowed us to turn out of friction pins
    - Ballistic Nylon on the bumpers has lower coefficient of friction and thus we can easily slip away from defensive robots

- Hall Effect Sensors on the Transmission
    - Performs motor to wheel speed matching when shifting gears for faster engagement

# Ball Manipulator

With the game oriented around a single game piece, we knew that we needed to effectively manipulate the ball in order to make our cycles more efficient. We also recognized that strategy was going to be critical in this game so we designed our robot to be as versatile as possible.

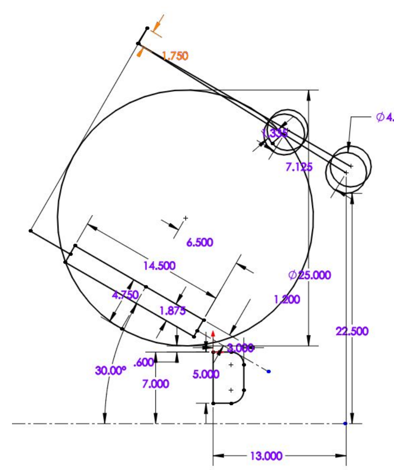
## Required Functions:

- Ability to adjust to the evolution of the game and changing alliance partners
- Ability to assist Alliance Robots
- Wide intake to easily pick up ball from the ground and human player
- Ability to manipulate the ball on the front and back sides of the robot
- Catch from partner as well as self-catch

# Intake

The Intake Rollers control our manipulation with the game environment, thus we found it important that this subassembly performs perfectly.

Our optimization philosophy is evident in this subassembly because we took a known solution and re-engineered it to perform better.



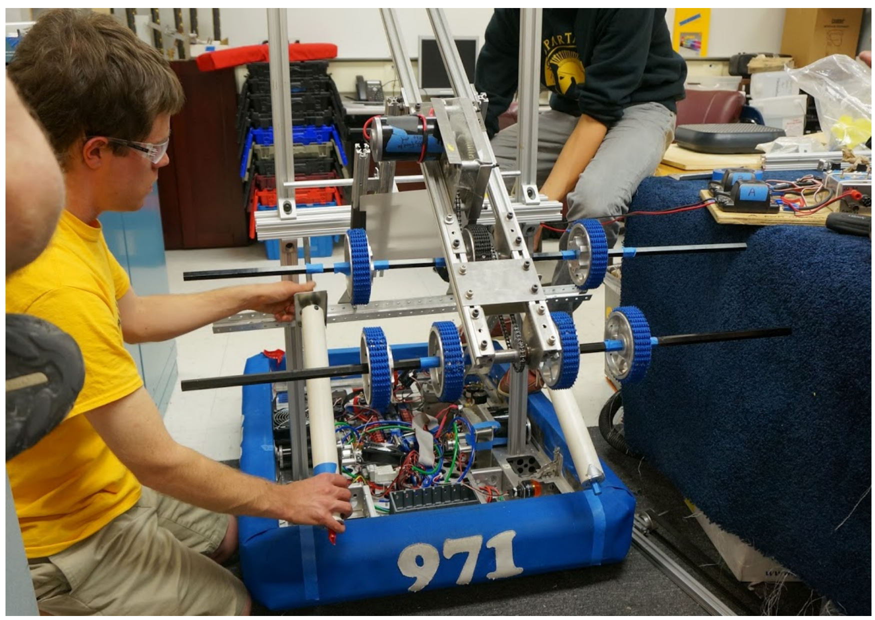

## Required Functions

- Have the widest pick up area possible
- Ability to pick up balls in tight locations
- Ability to pick up balls at high velocities
- Ability to minimize and withstand any robot contact

# Prototyping

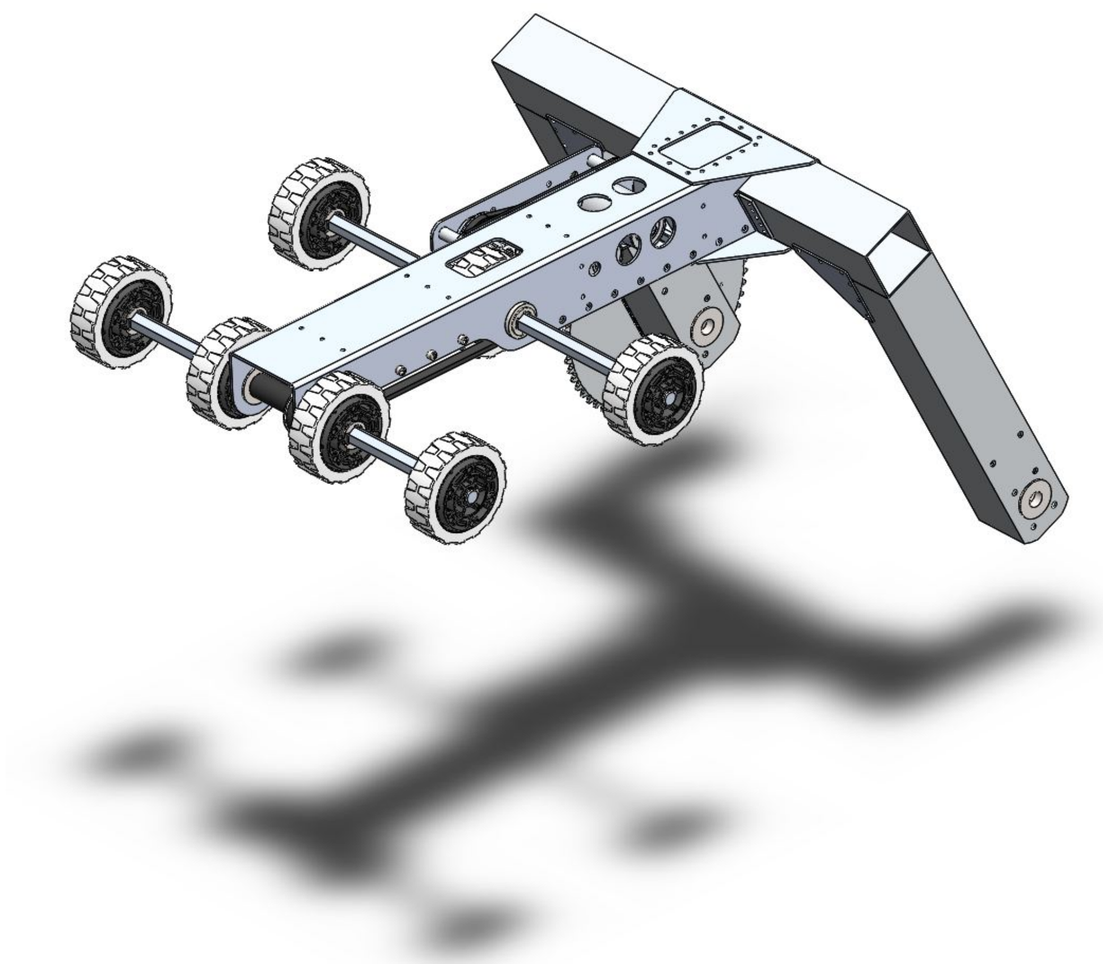
- First hypothesized what would work
  - Rollers
- Tested top rollers and side rollers
  - Side rollers pushed the ball away
- Tested to confirm/see how it picked up that ball
- Determined optimal location for wheels

- Made a more permanent prototype
  - Mounted to previous drive base
  - CADed up and made parts with new in-house machining equipment



# Final Design

- Made to withstand getting hit by another robot.
- Rollers spin with 25 ft/s surface speed in order to intake while moving at high velocity
- Motors are completely contained in top to prevent damage.
- All components other than the tube itself (timing belt, wheels, shafts) are mounted with bolts for easy replacement
- Testing showed that the intake works well.

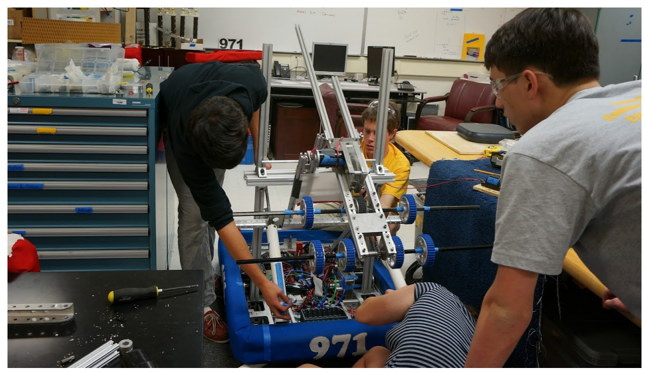


# Centering Tusks

The centering tusks are another way we found to improve our intake performance to give us a competetive edge. The tusks essentially widen the intake and catching area while also ensuring that the ball is centered on the shooter. This subassembly is a distinct feature of our robot that epitomizes the quality engineering on our team.

## Required Functions

- Ability to center the ball when shooting for consistency
- Wide intake area
- Strong so that when any part was outside of the base it could withstand hits

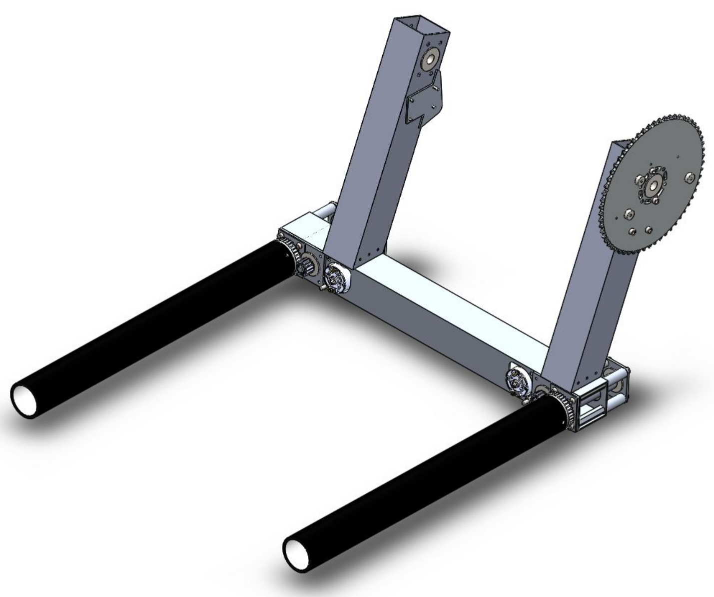



## Prototyped

- Originally tested passive rollers so the ball would “squirt” into the center of the robot
- Through rapid prototyping, it was found that we could widen the catch and collection range by powering the rollers

## Design

- Protected motors located inside the tube.
- If hit, the tusks will turn the robot before they break.
- Centers the ball on the shooter.



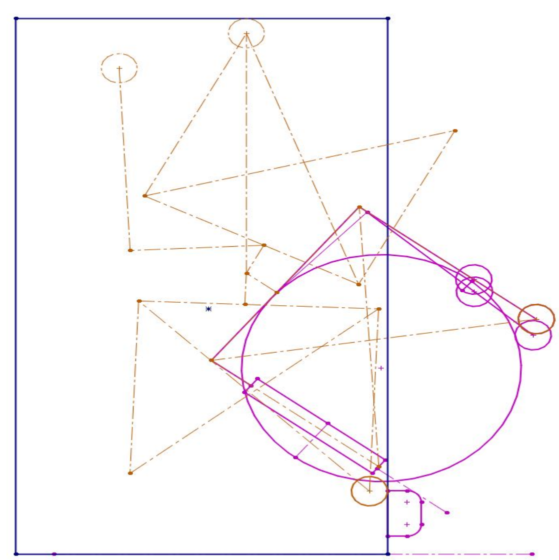
# Split Claw

The split claw is the most defining feature of our robot. The split claw fixed many of the design issues we had identified.  In the process, it added a level of mechanical and software complexity that needed to be carefully designed for in order for the resulting design to be successful. The split claw embodies our engineering process because it shows how meticulous perfectionism, can produce a solution.

## Required Functions:

- Ability to manipulate the ball well.
- Ability to fold into the protected tuck position.
- Ability to shoot and roll the ball forwards and backwards.
- Ability to open the claw for a catch.

## Decision Process for Split Claw



**The Dilemma - We needed**

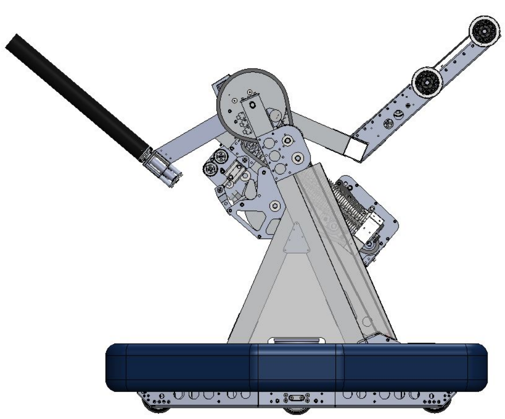
- Large range of motions.
- Tuck position to roll ball backwards.
- To always be under 5'.
- Possible intake position relative to frame
    - CAD drawing determined it was feasible.

**The Solution**

- Had to split claw into two halves
- Each claw had to rotate up to 330 degrees
- We took inspiration from


**http://www.simbotics.org/media/photos/2008-waterloo-regional/2307**

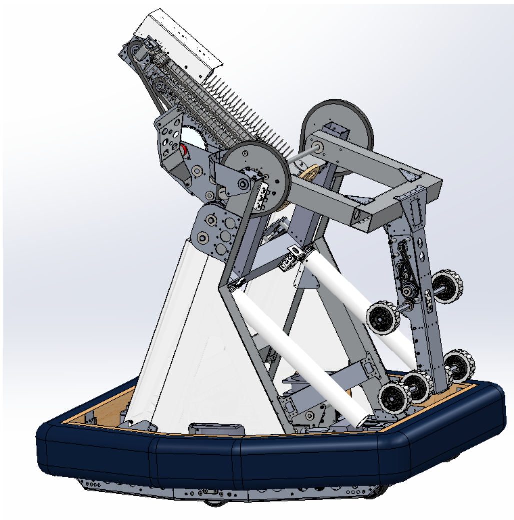
# Design



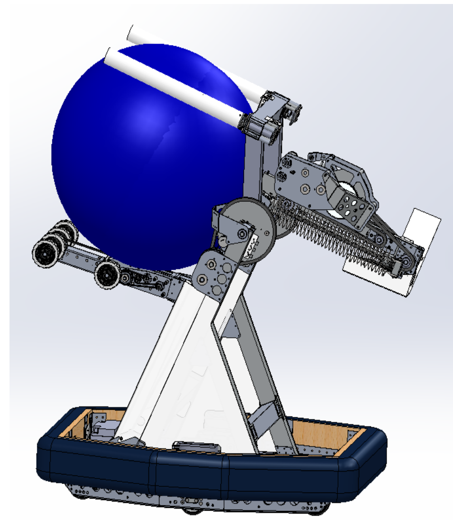
- Wide catch
- Claws open when shooting to allow ball intake
- Each claw 330 degrees of motion
- Includes tuck and reverse tuck positions
- No pneumatics reduces air needed

# Split Claw Position Montage

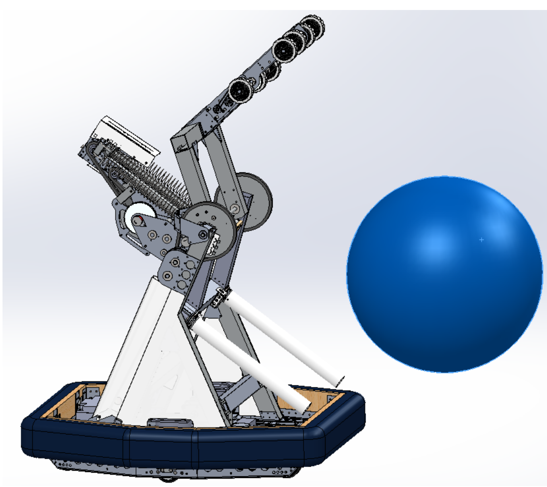
Tuck position.



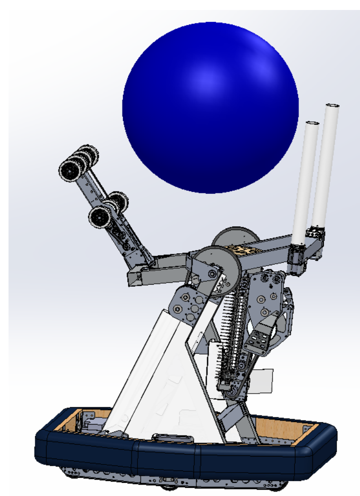
Backwards shot Position.



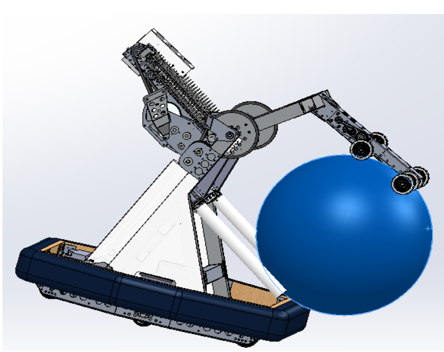
Bouncing ball.



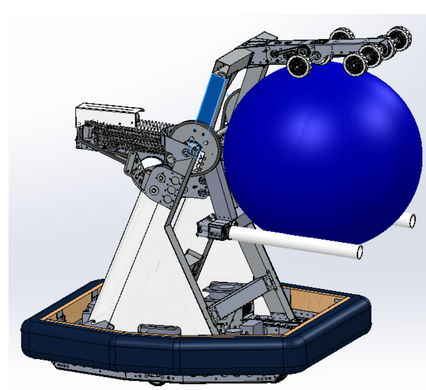
Catch Position.



Intake Position.



Front Shot Position.



# Shooter

The shooter is also unique to our robot because it involves a creative way of dispersing the energy not put into the ball by using a bicycle disk brake. Through our strenuous design process, we found an innovative solution that met all of our design requirements.

## Required Functions

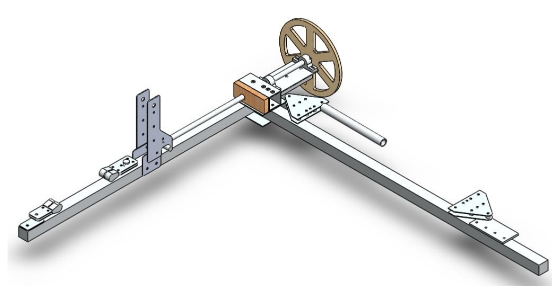
- Ability to shoot from the white zone for autonomous
- Ability to change shooter power
- Ability to safely dissipate extra shooting energy
- Ability to shoot at multiple angles

## Prototype/Theorize

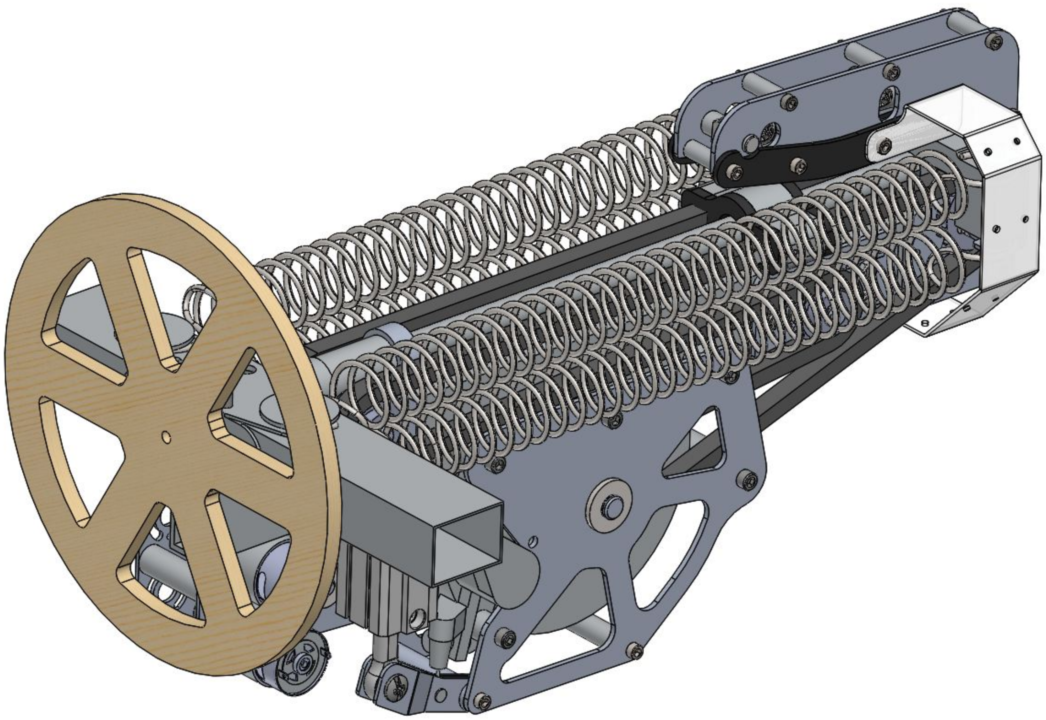
- Initially chose a linear shooter to work well with roller claw design
- First made a wooden linear shooter
    - Proved that a linear shooter could work by testing and high speed video
- CADed up more permanent design
    - Was able to get shot consistency
    - Allowed us to determine the final design

**High speed video image**

- Created more advanced prototype
    - Packaging springs and plunger
    - Springs needed to start pulled back all the way to fit ball in claw



# Design



- Variable shot power determined by adjustable hardstop
- Uses a disc brake to dissipate extra energy
- Hall Effect sensors are used to determine when the plunger is pulled back and loaded
- Spring powered
- Uses motors to pull back springs

# Summary

Because of our prototyping, design decision process, attention to manufacturing and assembly detail, and programming controls, we have been able to design an effective, robust, and reliable robot to play the FIRST 2014 game, Aerial Assist.