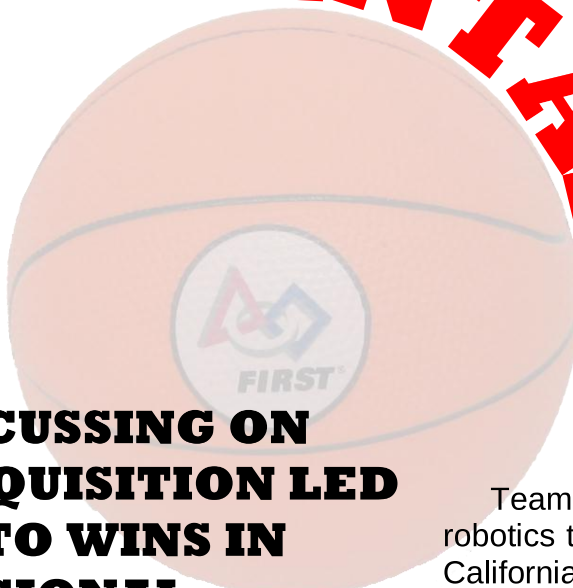
Reaching the finals in a FIRST Robotics Regional competition requires a solid robot and a bit of luck. Winning two consecutive regional competitions requires a level of play that few teams reach.

TEAM 971

A NOVEL TAKE ON AN INTAKE



HOW FOCUSSING ON BALL ACQUISITION LED A TEAM TO WINS IN TWO REGIONAL COMPETITIONS AND A BIRTH AT WORLDS.

Team 971 is a high-school FIRST robotics team based in Mountain View, California. Their 2012 robot, “Renegade” featured a unique intake system was a large contributor to their success.

A lengthy design and prototyping process determined that having a fast and reliable ball intake. The team even used a camera capable of recording video at 1000 frames per second to determine how balls moved through intake systems to understand where problems might appear.

Even after the team built their intake system, constant iteration with their practice robot improved upon their initial design. That improvement continued throughout the season and up to World Championships.

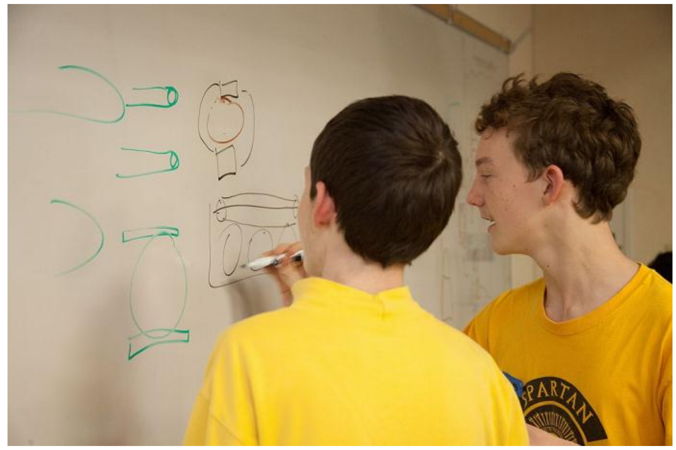
Early in the design process, Spartan Robotics team members realized that they needed to focus on a robust and fast ball pickup mechanism. Through prototyping and testing, they realized that the outer covering of the ball would create jamming problems for mechanisms that funneled balls into a single row if the balls were allowed to touch one another.

In addition they realized that bumper rule requirements would limit them to a very narrow intake if they picked up through the bumper. They also decided that their bumpers would need to be at the minimum allowable height to help prevent other robots from pushing or lifting them, and to prevent balls from being trapped under the robot.

Next, the team generated a set of design requirements for the ball acquisition system:

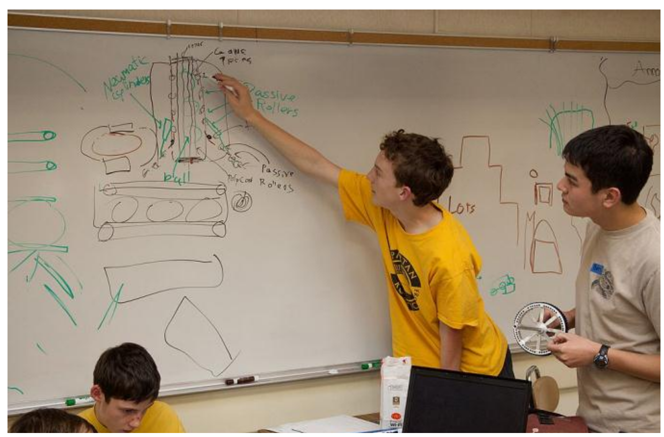
- Must retract quickly to avoid damage
- Fast ball acquisition
- Simultaneous ball pickup
- Must never jam
- Easy to build and maintain: simple
- Sturdy
- Lightweight
- Could reach corners of the field

Next, they reviewed designs from previous games. Finally, they began to prototype.



Students brainstorm to develop initial concepts that will meet the design requirements of their intake.

The team worked together to design and integrate the components to fit together as a whole. Here, they work on their ball tower design.



Group discussions kept everyone on the same page.

Prototyping All The Problems

The team narrowed down their design choices to eight different possibilities. Each of these was sketched up in Solidworks, analyzed, and reviewed. The team settled on one of the concepts to focus on, then started to build a mock-up of that system using scrap material.

They decided on an over-the-bumper acquisition system to maximize the width of their intake. That presented them with another problem. The team already knew they wanted to avoid a system that funneled the balls together in a single row. That led them to create a unique horizontal belt system that balls would be deposited on by the ball intake mechanism.

The prototypes that 971 made still exhibited some of the ball jamming that they were trying to avoid. Most of the jamming was occurring when balls would rub together. The outer covering was so sticky that the balls would not roll while touching one another.

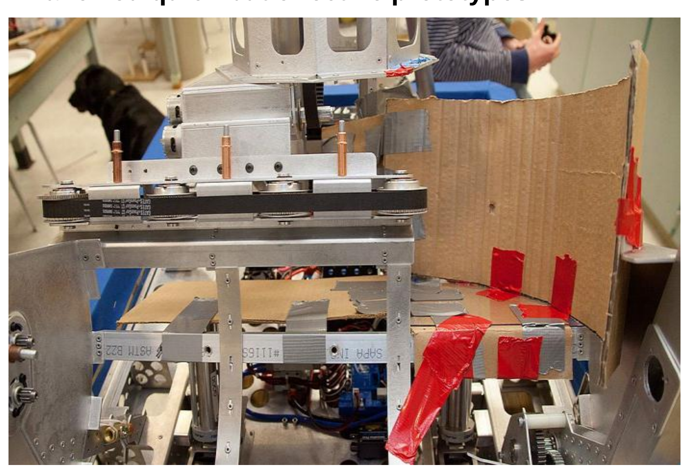
Spartan Robotics worked extensively tuning the size and shape of the ball path and trying different materials for the walls. They also worked with a number of different belt speeds to try to determine which worked best.

Intentionally overloading the conveyor helped determine what would fail first.

Initial tests showed where their concepts were going to have issues with jamming.

The team tweaked components and measurements until the balls began to flow through their system.

Additional iterations of their prototype helped reduce jamming. Duct tape and cardboard allowed quick but effective prototypes.



The ball pickup system was made out of hollow rectangular tubing.

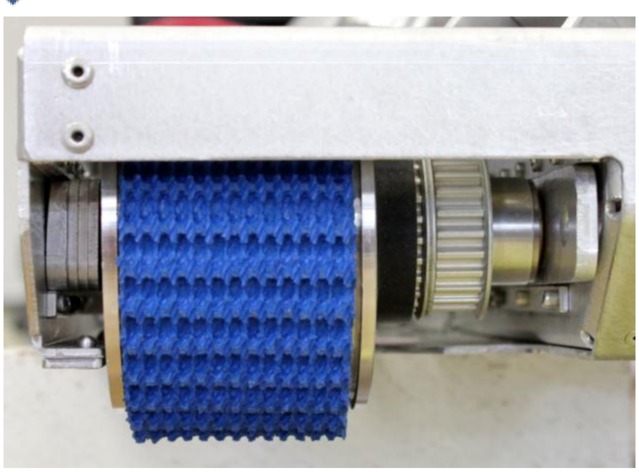
The team used timing pulleys on the drivetrain. Also note the new tread mounting method, a collaborative effort that is now on sale at AndyMark.

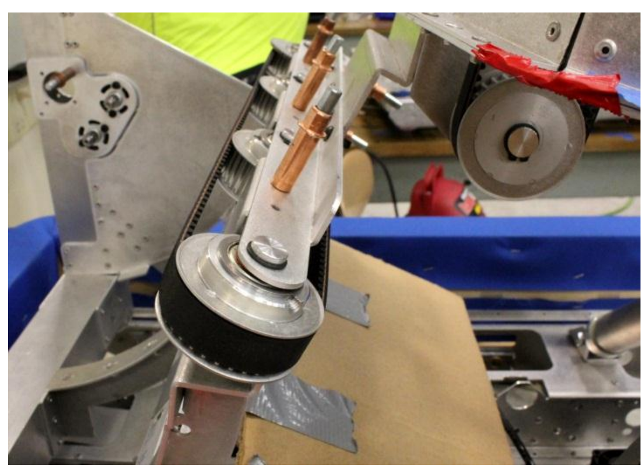
The team used sheet metal heavily in their frame, but chose to make their ball acquisition out of large rectangular tube for strength.

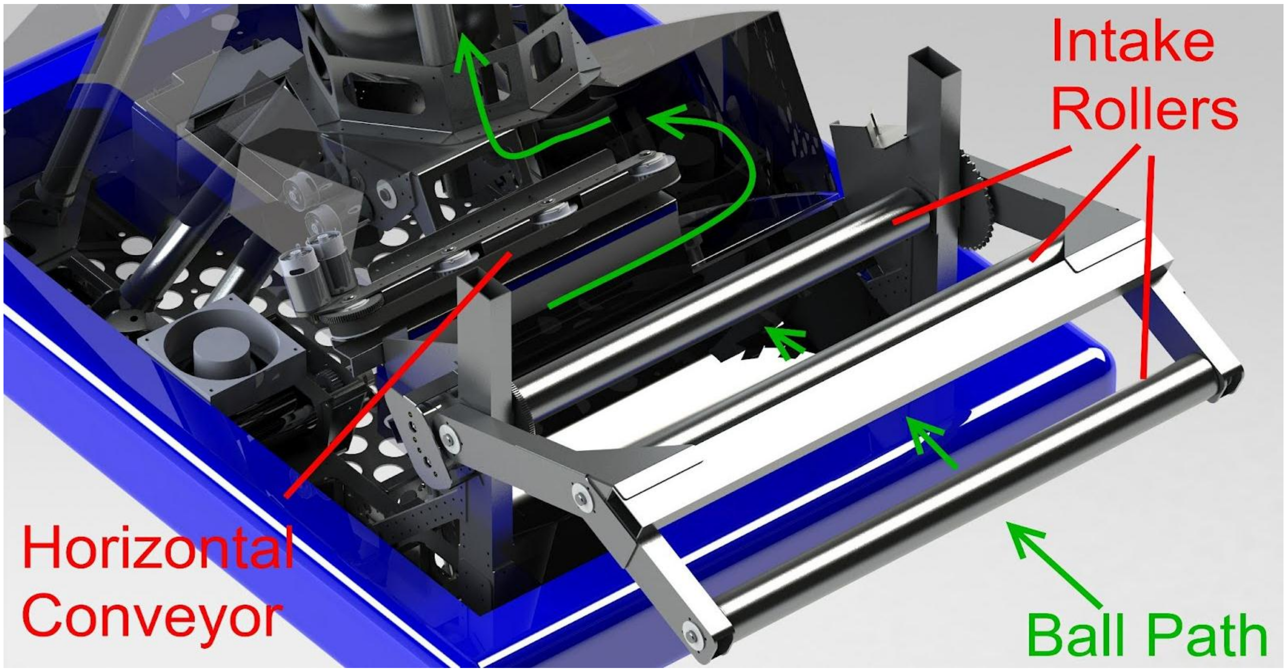
971’s team members also considered the reliability of the ball acquisition mechanism: they decided against running their rollers with urethane cord. Urethane cord is common in FIRST Robotics because it is inexpensive and easy to form into belts of any length. However, urethane cord has a tendency to walk sideways on rollers and come off. Instead, they ran their belting internally on the arm.

The team also used timing belts and pulleys on their drivetrain. Timing belts are toothed-belts that ride on toothed pulleys. They are extremely durable and weigh little. They require addition design time to insure the length between pulleys is correct, because they cannot be cut and then spliced.

The drivetrain and ball handling systems were driven with lightweight timing belts.







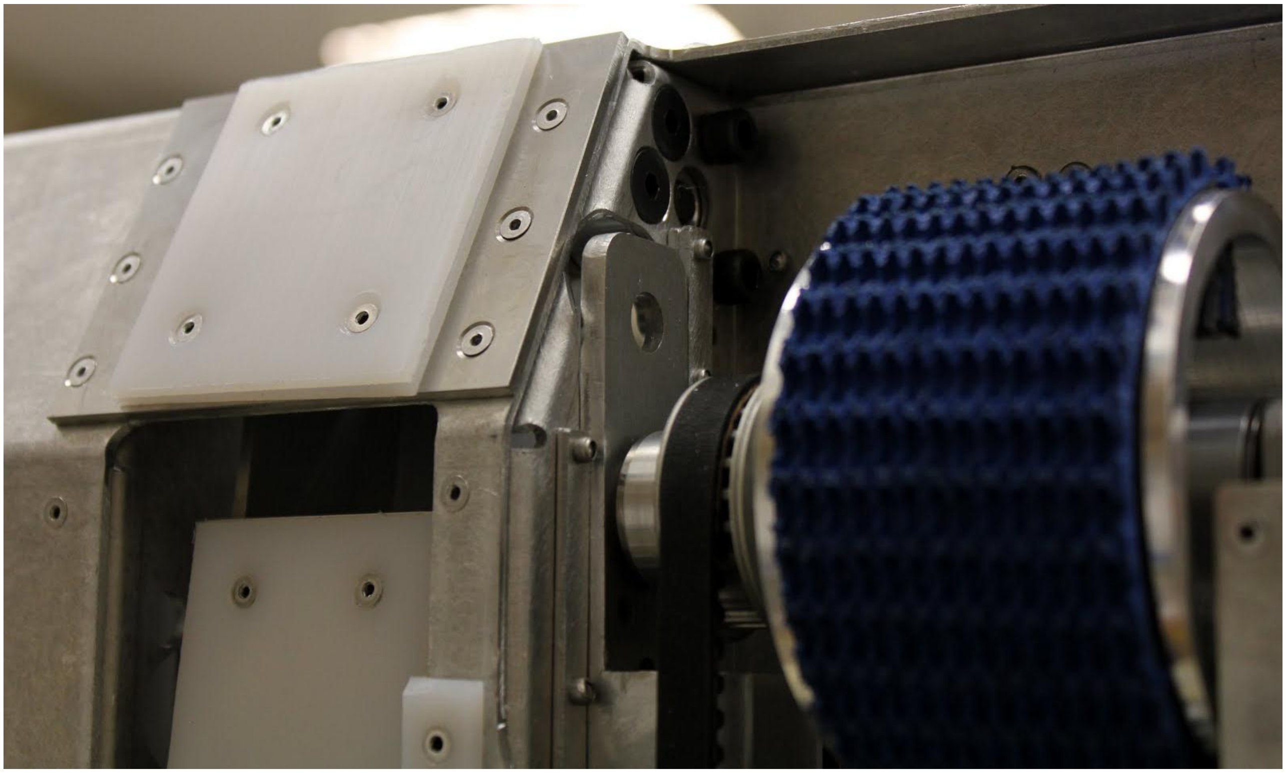
An accurate 3D model allowed seamless integration of all the components and made potential design revisions much easier.

The true innovation in 971's ball pickup mechanism was the way in which balls transitioned from a three-wide configuration into a single row of balls that could be fed into the vertical tower.

Balls were pulled over the bumper, then deposited on the angled surface leading to the horizontal conveyor. Gravity helped separate the balls on their way to the conveyor, but if that failed then the horizontal motion of the conveyor served to further separate the balls.

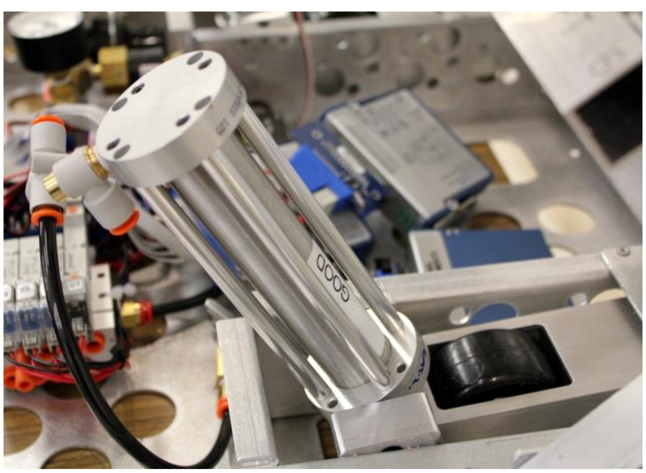
The speed of the rollers acquiring the balls onto the horizontal conveyor, and the speed of the horizontal conveyor itself were both tuned to smooth the flow of balls into the vertical tower.

This resulted in balls being fed single file into the vertical tower. An optical sensor at the entrance to the vertical conveyor insured that the balls were spaced correctly for the shooter.



Slick plastic plates were attached to the robot frame in the location that it would strike the bump as the robot traversed it. The rivets were countersunk to provide a perfectly flat surface.

Pneumatic cylinders actuated drop-down wheels to lift the front of the robot to the height of the bump.

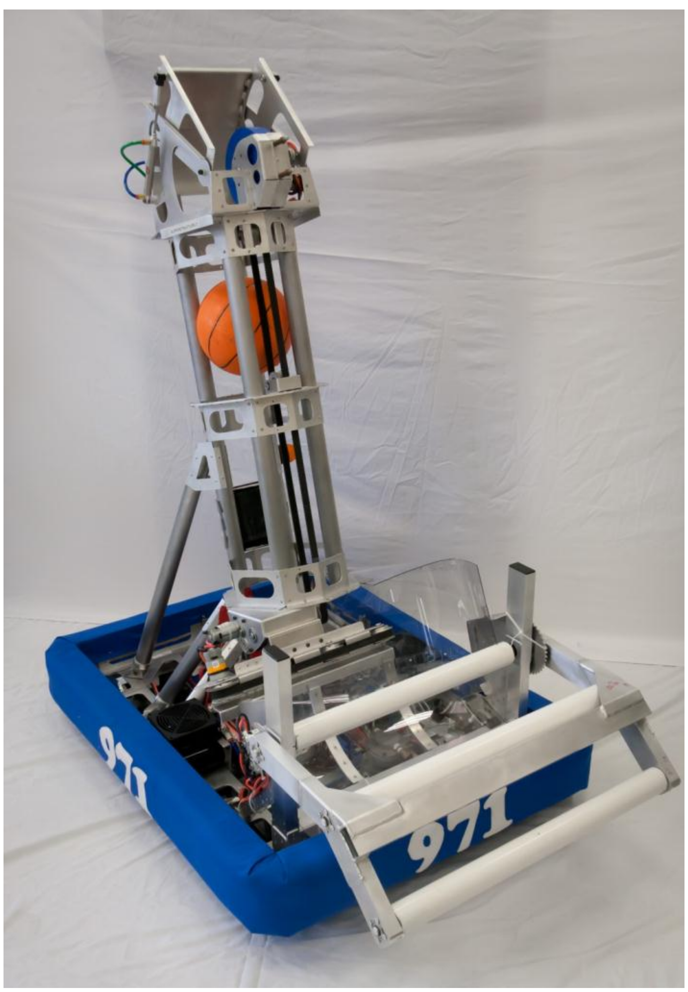


Having a superior ball collection system wouldn't help the team unless they could get to the balls. The team attached skid plates to the underside of their robot.

First, however, they had to lift the front of the robot above the height of the bump. Pneumatic cylinders were installed on the robot that actuated wheels under the front of the robot. This lifted the robot's front and allowed them to push up onto the bump.

The chassis was designed so that even with the front end of the robot on the bump, the rear wheels stayed in contact with the ground to push the rest of the robot over the bump.

Plastic runners ran the length of the robot so that once the robot was on the bump, it could continue to slide its way across.



Team 971 correctly identified the difficulty faced by teams moving balls through acquisition systems as one of the key design challenges for the 2012 game. Their unique and elegant over-the-bumper to horizontal conveyor system proved to reliably meet that challenge.