

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.



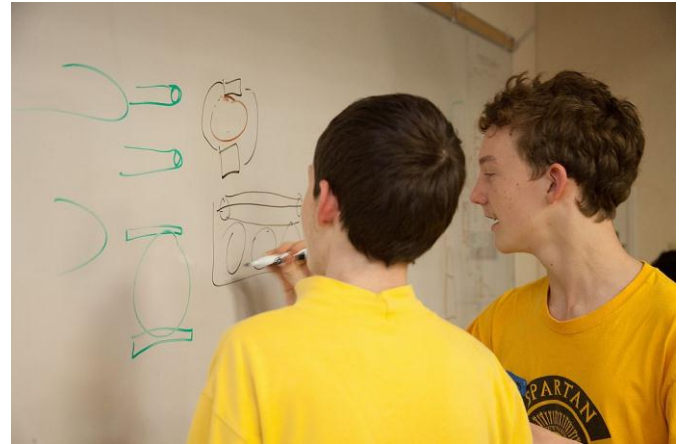
Early in the design process, Spartan Robotics team members realized that they needed to focus on a robust and fast ball pickup mechanism. Through prototyping and testing, they realized that the outer covering of the ball would create jamming problems for mechanisms that funneled balls into a single row 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 balls through an opening in the bumper. The team also made low-slung bumpers a priority to help prevent other robots from pushing or lifting them, and to prevent balls from being trapped under the robot. This ruled out picking balls up without lifting them over the bumpers.

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

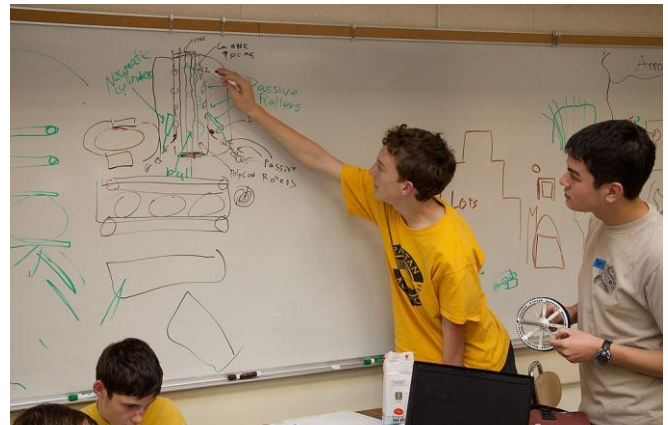
- Retract quickly to avoid damage
- Fast ball acquisition
- Simultaneous ball pickup
- Must never jam
- Easy to build and maintain: simple
- Sturdy
- Lightweight
- Able to reach corners of the field

They also researched 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. After the review the team was able to settle on one of the concepts and 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.

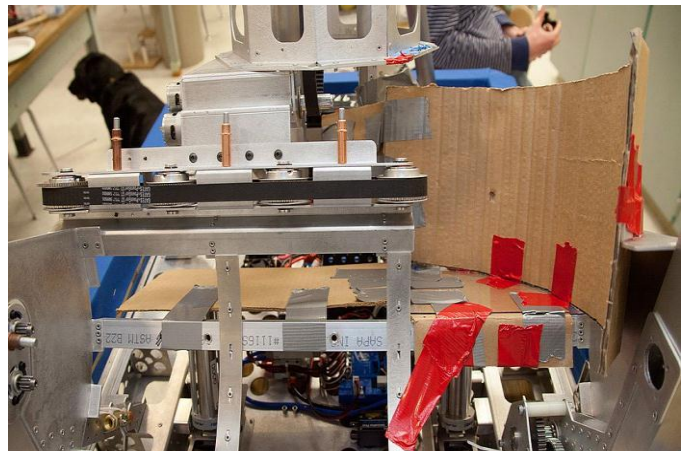


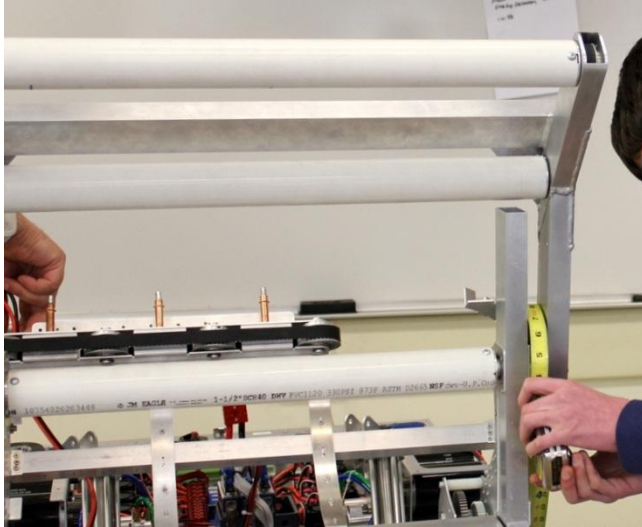
↑ Initial tests showed where their concepts were going to have issues with jamming.

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

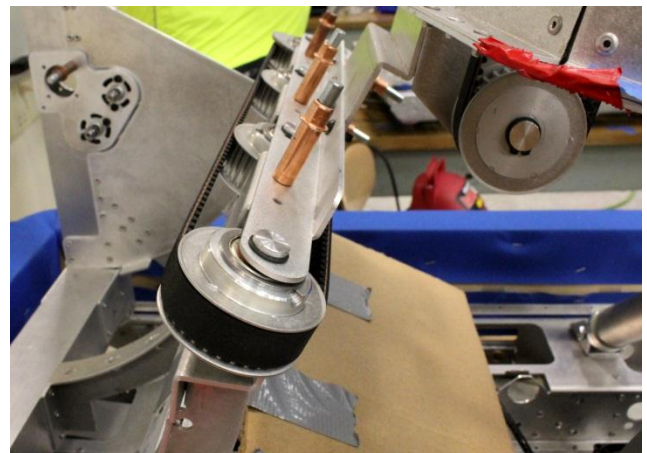
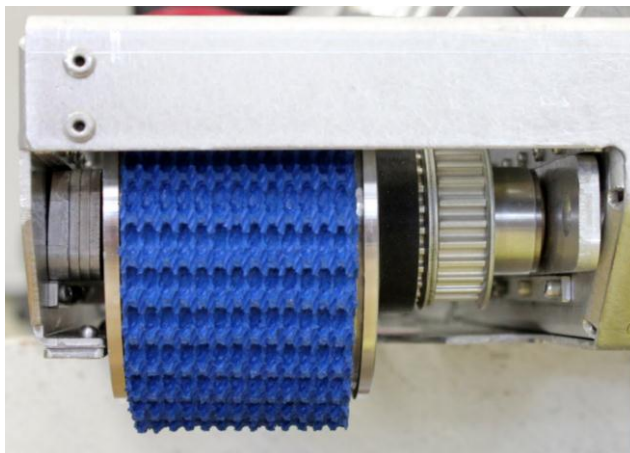
971's team members also considered the reliability of the ball acquisition mechanism: they decided against running their rollers with urethane cord. Urethane cord is common in FIRST Robotics because it is inexpensive and easy to form into belts of any length. However, urethane cord has a tendency to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

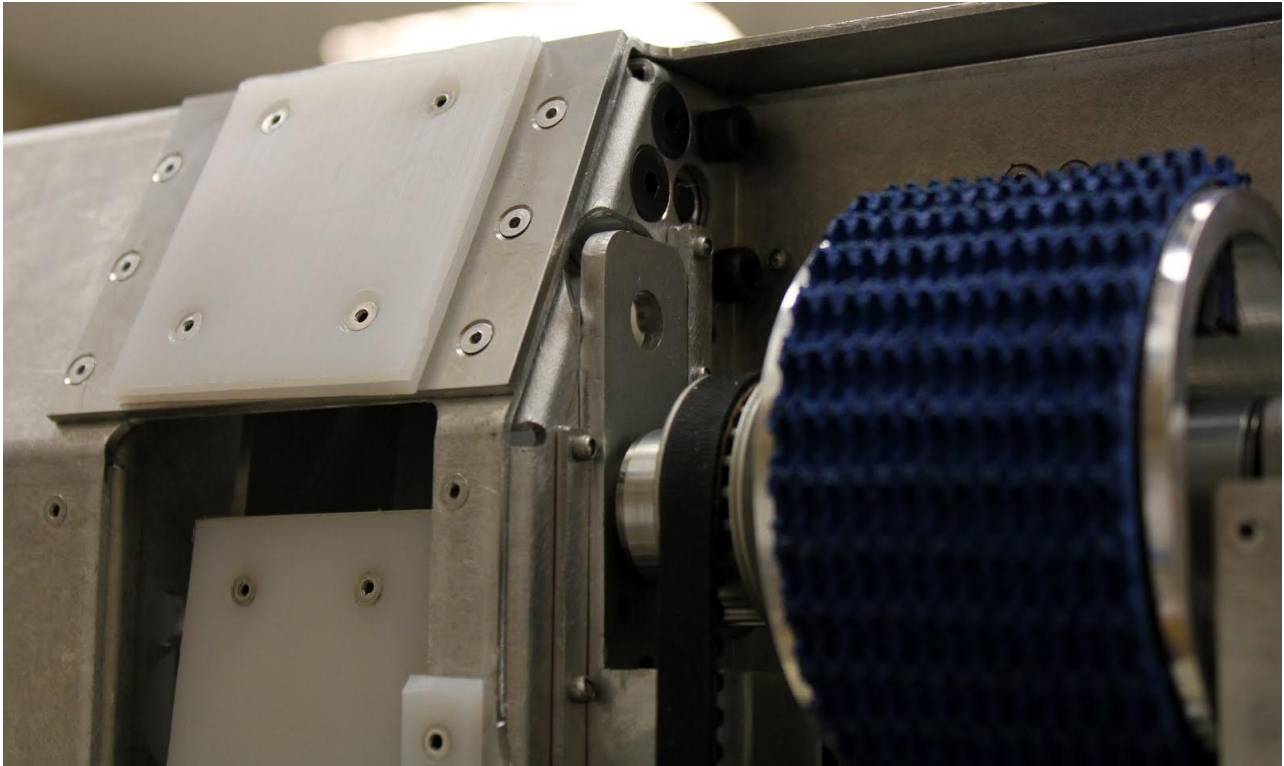
↓ The team used timing pulleys on the drivetrain. Also note the new tread mounting method, a collaborative effort that is now on sale at AndyMark.



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

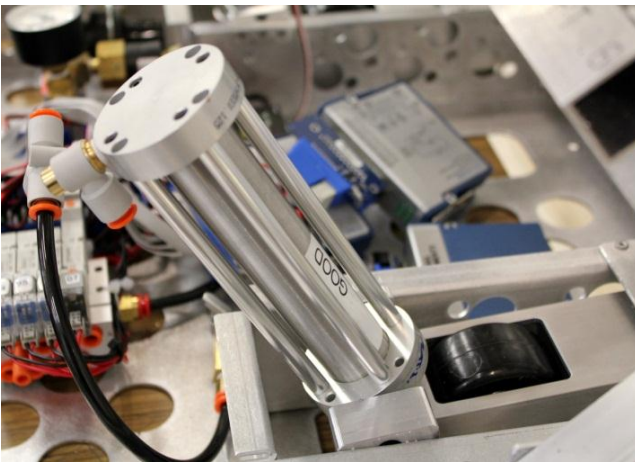
↓ The drivetrain and ball handling systems were driven with lightweight timing belts.





↑ 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.

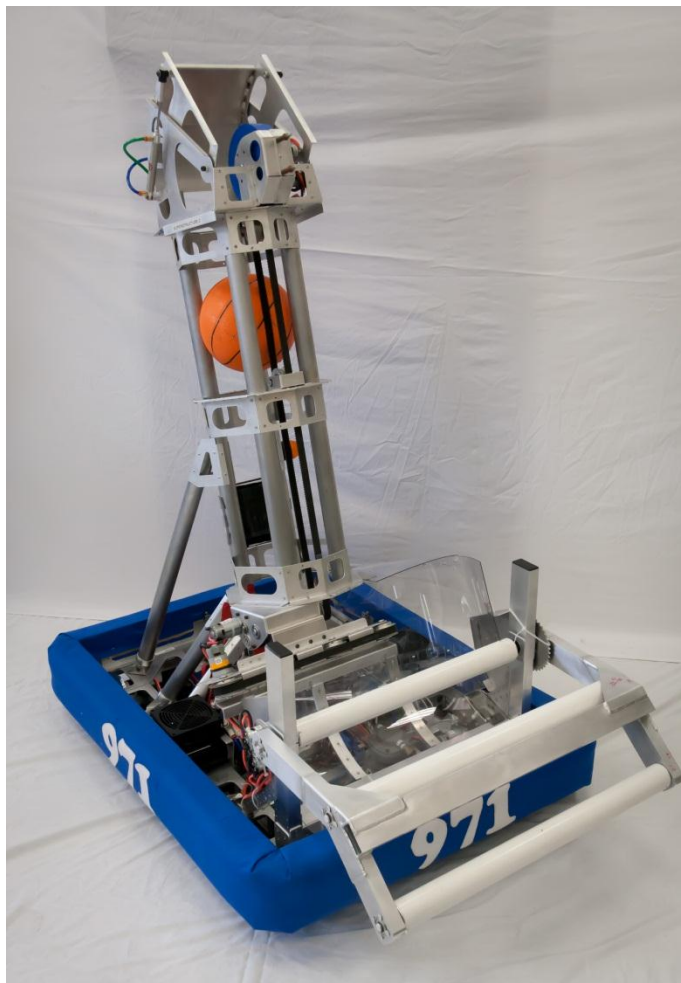


→ A Bump in the Road

Having a superior ball collection system wouldn't help the team unless they could get to the balls quickly. The team designed an elegant method to slide over the center barrier.

First they devised a method to lift the front of the robot above the height of the barrier. Pneumatic cylinders were installed on the robot that actuated wheels under the front of the robot. This elevated the robot's front. They also attached skid plates to the front of the robot to help it slide up and over the barrier.

Plastic runners ran under the robot so that once the robot was on the bump, the wheels could keep pushing and the rails would slide across the barrier quickly and easily.



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.

When the intake was combined with a highly mobile robot that could easily traverse the bump and shoot accurately, it resulted in a combination that was tough to beat.