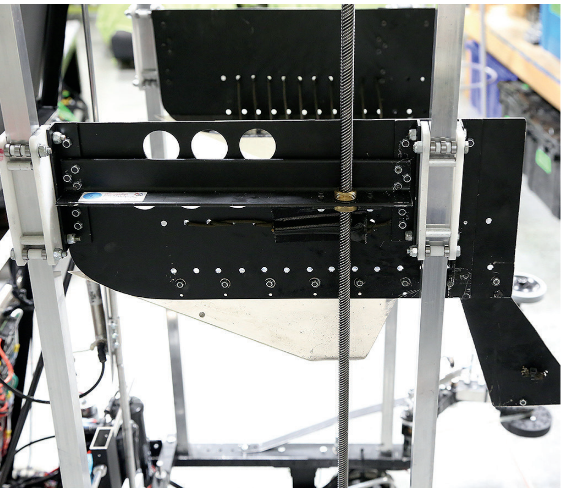


A rotating lead screw powered each side of the elevator carriage.

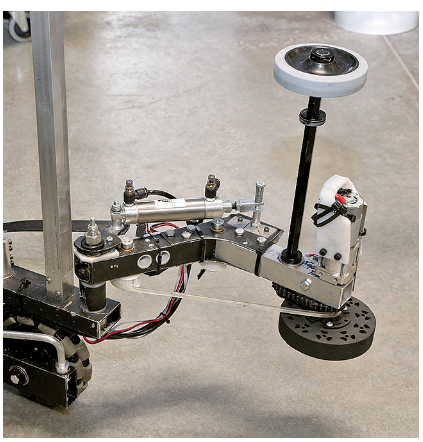
Also, during this phase a chain-in-tube system was refined to protect drive mechanisms from entanglement. This system was originally designed for the drive motors but later was also applied to lift totes. The high fidelity of the prototypes during this phase ensured the effectiveness of the improvements.

Progressing from prototype to becoming competition-ready was the third phase of the design process. This phase required the application of the most advanced machining techniques on the mill and lathe to fabricate components. Improvements to the practice robot were discovered and incorporated into the design of the competition-ready robot.

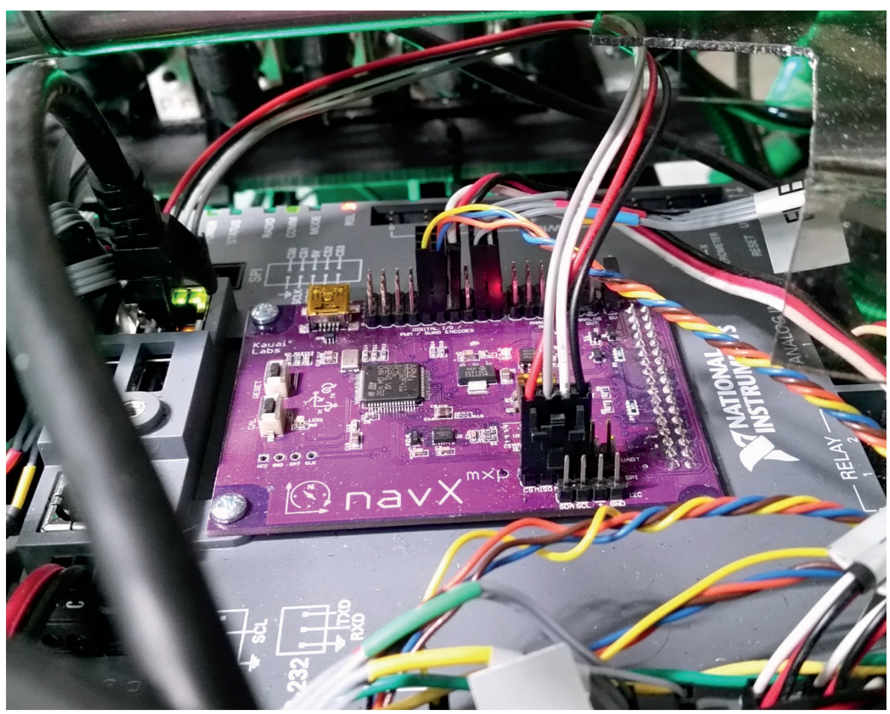
The elevator lift rails were fabricated from aluminum tubes, a material commonly available at any hardware store. A Delrin bracket held roller bearings against the tube to produce a low friction fit. The elevator was lifted by a rotating lead screw. A lower lip was added to the elevator to right containers that had fallen — a simple addition with significant impact. Testing of the system to ingest totes led to a realization that the intake wheels could be rotated in the opposite direction to move containers out of the way during the autonomous period. The use of existing systems for multiple purposes became creative solutions that were implemented with little cost.

ACHIEVING CONTROL WITH A NEW CONTROLLER

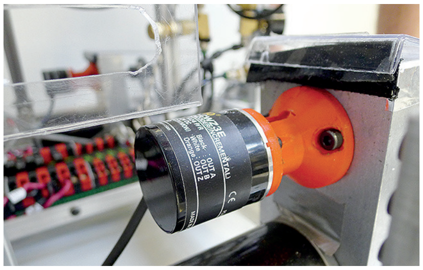
Scoring the maximum amount of points during the autonomous period was a team goal. FRC Team 624 rationalized that an investment in developing its control system would enable the team to excel during the autonomous period of play and benefit the team during the period when drivers controlled



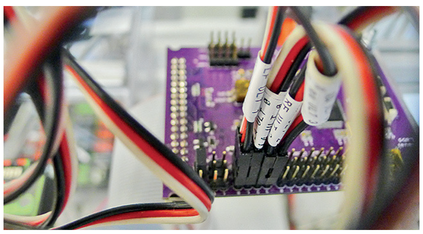
A combination of sensors and mechanisms made it possible to pick up totes in any orientation.



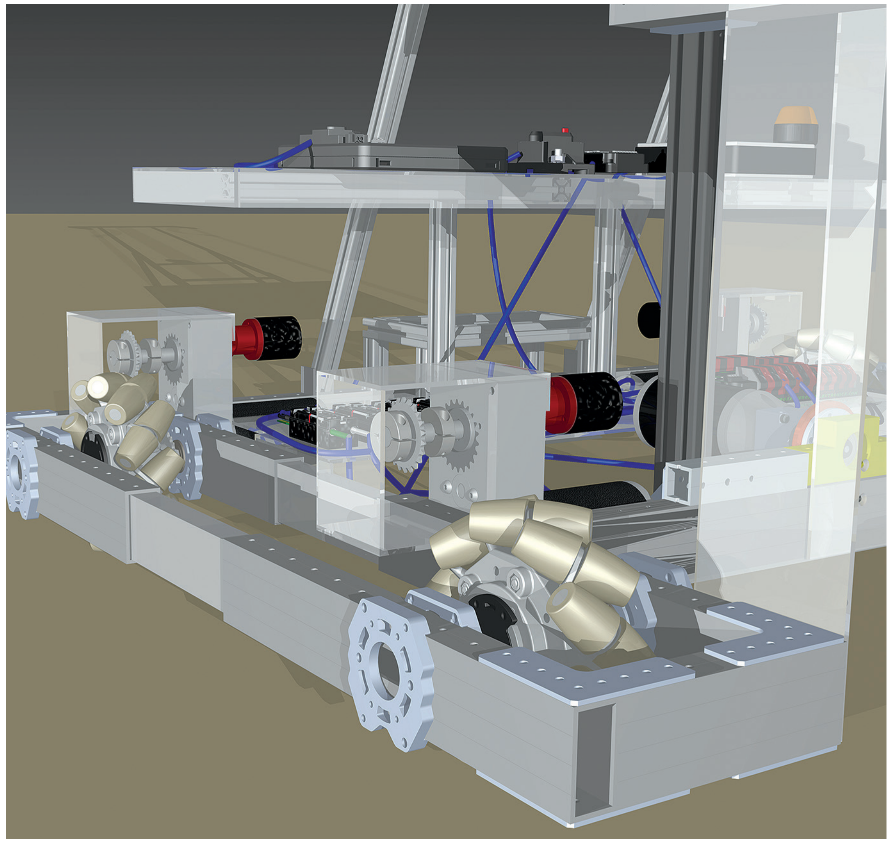
The navX MXP Robotics Navigation Sensor provided a method to increase the number of sensors used on the robot. This board seamlessly integrated with the NI roboRIO robot controller.



Rotary encoders reliably measured the rotation of each drive wheel. These were essential measurements needed to control the mecanum drive system.



The navX MXP Robotics Navigation Sensor provided three-axis accelerometer measurements and was a conduit for other sensor data.



Sensors, electrical panels, and control system components were included in the CAD drawings. This level of detail ensured that the electrical and control systems were integrated into the design process.

PROTOTYPING CONTROL SOLUTIONS

While all of the robot's mechanical systems were designed considering control aspects, two features in particular required special control functions: the drive system and the expanding chassis. Omnidirectional movement was achieved using mecanum wheels for the drive platform. To control the drive system, the power to each wheel was carefully regulated. Wheel rotation was monitored using rotary encoders installed on each transmission. These signals were combined with data from a gyro sensor on a navX MXP Robotics Navigation Sensor. This sensor connected to the myRIO Expansion Port (MXP) on the NI roboRIO robot controller. Data from all inputs was used to fine-tune the voltage for each drive system motor to achieve the desired directional and velocity control.

To increase stability while carrying a stack of totes, and meet the competition's transportation size requirements, the team designed a robot base with an expandable depth. This novel design produced a chassis that expanded six inches once the robot was placed on the competition field. The expansion was accomplished using rectangular Delrin beams that ran inside the four aluminum frame members. When the robot was on the field, the frame was extended and the Delrin inserts were locked to the aluminum beams. From a controls perspective, this design feature required flexible connections for the control and power systems located on the front of the robot.

The controls sub-team employed the concept of prototyping to build the control system. This process began with the construction of a prototype controls board equipped with all of the elements in the power, monitoring, and control systems. The proto-board provided students with an easily configurable platform to learn how the new control system functioned and to practice control methodologies. Signals from sensors and motor controllers were used to create feedback algorithms for each of the robot's functions. This board was temporarily fitted on the drive base as soon as it was constructed to quickly experiment with control code on the real drive system.

The entire robot was designed using Autodesk Inventor computer-aided design (CAD) software. One advantage of having the complete robot available as a CAD model was the team's ability to establish the electronics