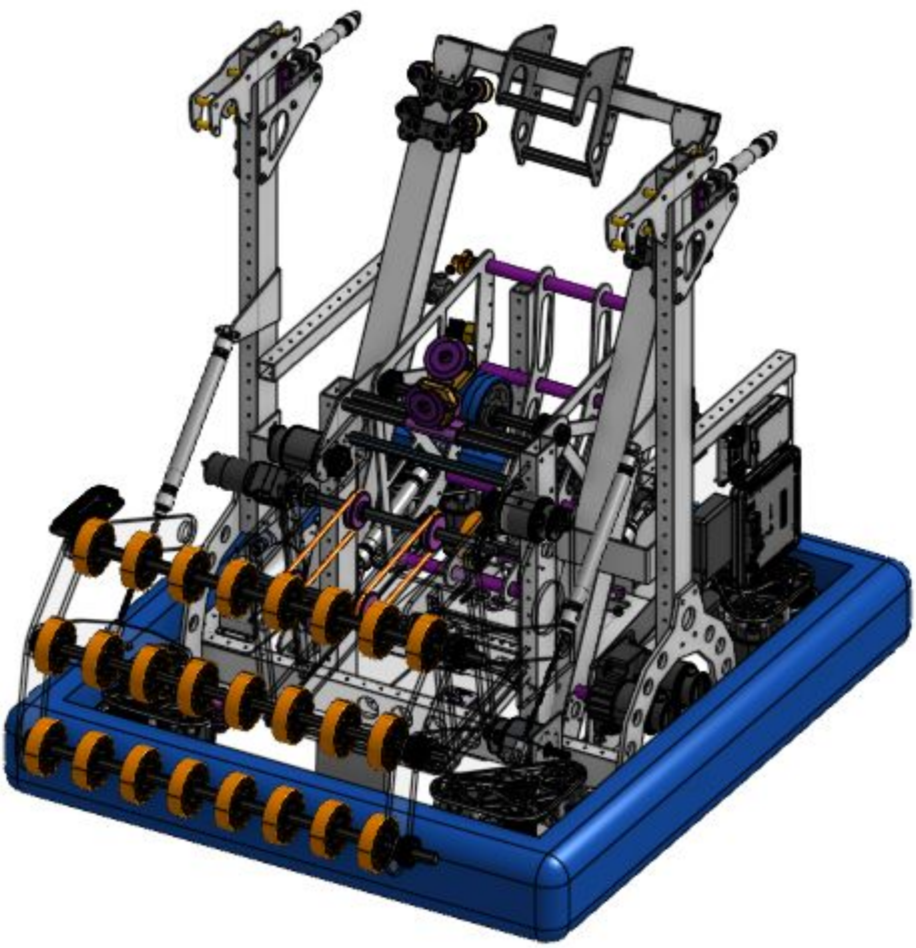
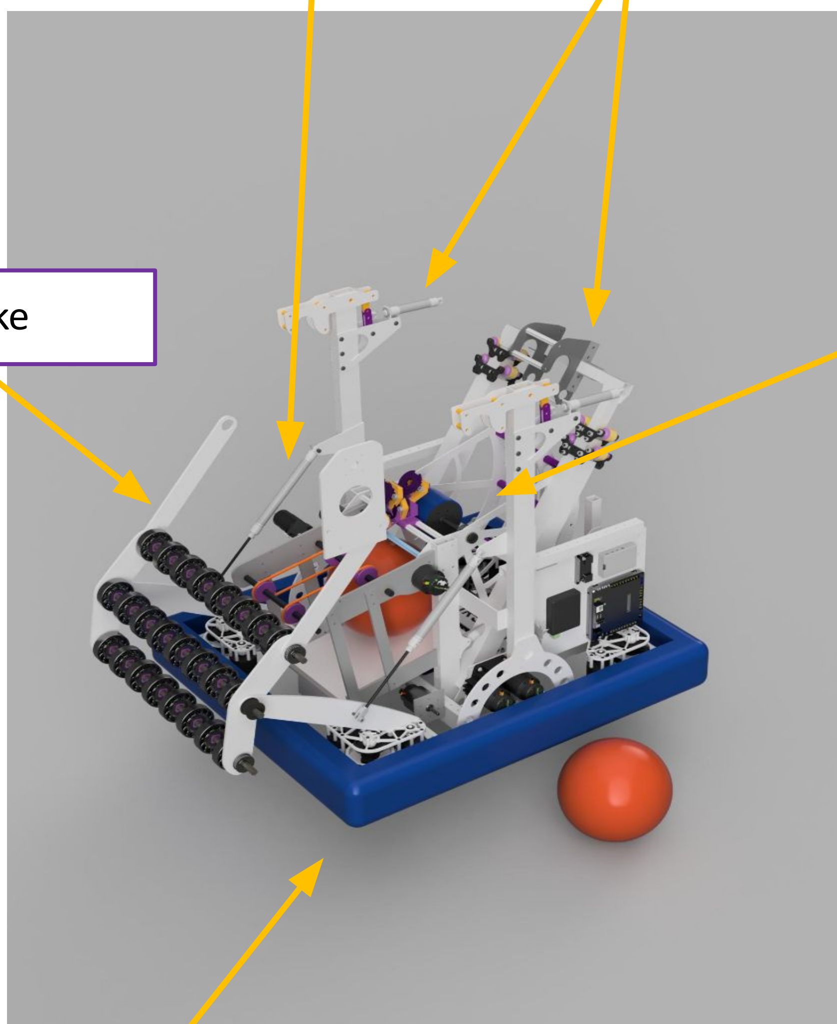
Issaquah Robotics Society

2022 Engineering Notebook



Our Robot



Conveyor System
Climber
Shooter
Cargo Intake
Swerve Drive

Table of Contents

Engineering Story

One of the goals of *FIRST* is to encourage students to apply the engineering process to various problems. Team 1318 believes that engineering is about developing and implementing a design both effectively and efficiently. We incorporate the engineering process into the design process for the entire robot, integrating engineering into entire meetings instead of just using this process for specific tasks.

We used the same adaptability and change required to be a good engineer to organize and run our team this year and accommodate the new FRC game challenge. To keep the design of the robot progressing, we organized into various sub-teams, each responsible for their own tasks, which were then integrated into the whole robot.

Our Product Cycle

To ensure efficient and effective engineering we follow a product cycle. This allows the IRS to continuously improve our robot while following a reliable process.

Brainstorming
1. Establish a strategy for the game.
2. Determine the most important tasks.
3. Conceive mechanisms that fulfill the tasks.

Design
1. Build CAD and physical mechanism prototypes.
2. Arrive at consensus on preferred designs.
3. Fine-tune and iterate prototype designs.

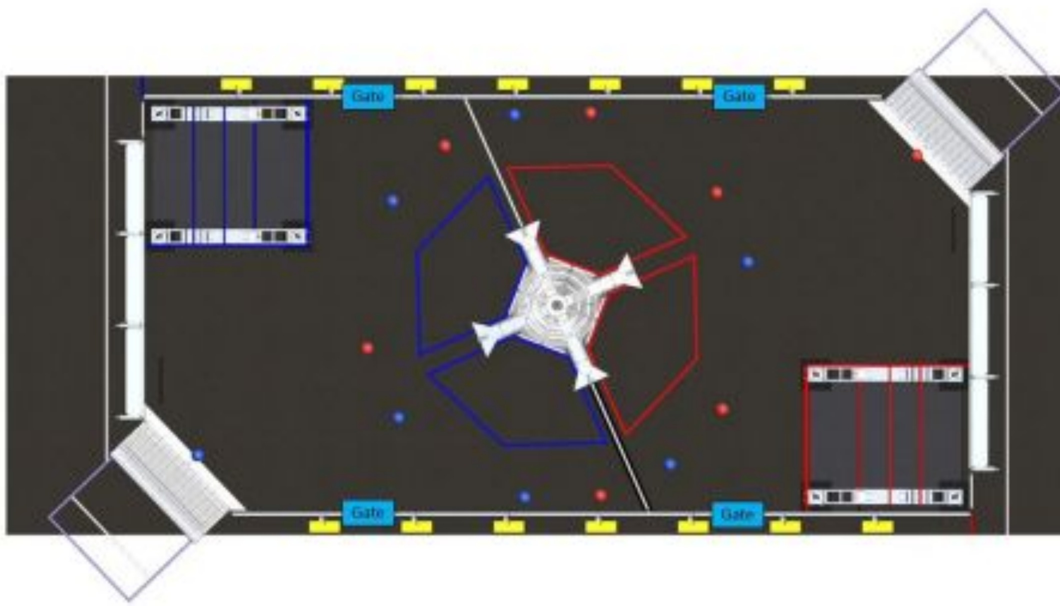
Build
1. Assemble the robot based off of prototype designs.
2. Fabricate & assemble mechanisms.
3. Build competition robot.

Robot Evaluation
1. Test each mechanism separately.
2. Run robot through integrated tasks.
3. Practice with competition robot at field.

Post-Competition Analysis
1. Analyze recruitment, training, and build season.
2. Evaluate student leadership models.
3. Review our design and engineering processes.

The Game

Summary



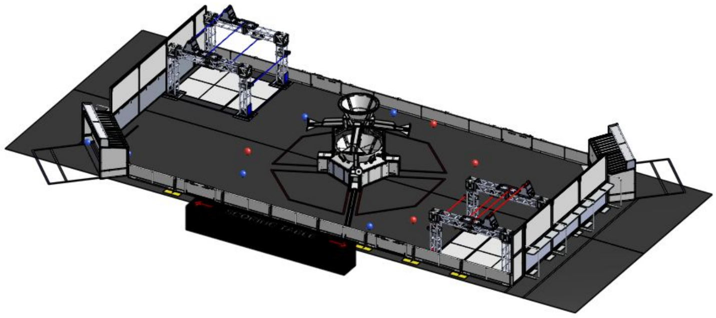
In RAPID REACT presented by The Boeing Company, two competing alliances are invited to process cargo for transportation.

Each alliance is assigned a cargo color (red or blue, based on alliance affiliation) to process by retrieving their assigned cargo and scoring it into the hub. Human players assist the cargo retrieval and scoring efforts from within their terminals. In the final moments of each match, alliance robots race to engage with their hangar to prepare for transport!

Each match begins with a 15-second autonomous period, during which time alliance robots operate only on pre-programmed instructions to score points by: taxiing from their tarmac and retrieving and scoring their assigned cargo into the hub. In the final 2 minutes and 15 seconds of the match, drivers take control of the robots and score points by: • continuing to retrieve and score their assigned cargo into the hub and • engaging with their hangar. The alliance with the highest score at the end of the match wins!

The summary above was extracted from the 2022 FRC Game Manual

The Game
Tasks & Points



Task	Autonomous	Teleop
Taxi	2	----------
Lower Hub	2	1
Upper Hub	4	2
Low Rung	-	4
Mid Rung	-	6
High Rung	-	10
Traversal Rung	-	15
Cargo Bonus	0	1 RP*
Hangar Bonus	0	1 RP*
Tie	------------------	1 RP*
Win	------------------	2 RP*

*RP stands for Ranking Point

Strategy Development

Game Analysis - Design

Critical Robot Functions

- Autonomous
  - Reliably score the single starting cargo
  - Score at least 2 more cargo than we started with
- Cargo - shooting
  - Shoot reliably into upper hub
- Cargo- intaking
  - Intake cargo from the ground while driving at top speed
  - Intake cargo quickly and efficiently - “touch it, have it”
- Cargo - intake to shooter - conveyor
  - Transport and store cargo from intake to shooter
  - Center cargo before reaching shooter
- Endgame - climbing
  - Climb quickly from the middle rung
  - Ensure security of robot while traversing rungs
  - Don’t fall

Strategy Development

Approach To Design

Team Prototyping Decisions

Climber CAD Model

Intake Prototype

Drivetrain Fabrication

Full Robot Design

Our robot began in prototyping. To achieve our final robot, sub-teams formed, each testing out prototypes or systems which eventually developed into our final mechanisms and robot.

- Task Identification
- Team Prototyping
- Prototype Evaluation
- Focused Prototyping
- Robot Mechanism

A summary of our prototyping process

3D Printing

Hardware and Prototyping

Prototyping

This year, our climber design was prototyped using printed parts. This enabled accurate testing of the over center linkage.

Hardware

We designed and printed many of the pieces of hardware used on our robot this year. 3” mecanum wheels printed in PLA, with TPU rollers are used on the intake. TPU parts are also used to plug into our electronics and protect them. Many pieces were designed and printed in order to assist in wire routing throughout the robot. We also printed many spacers for various subsystems.

Hardware

Drive Train

Needs	Wants
Navigate different paths on field	Optimize maneuverability
	Balance maneuverability with stability

Possible Ideas

MK4 Swerve Module	MK4i Swerve Module
Fast, maneuverable	Fast, maneuverable
More exposed motors	Motors protected
Higher center of gravity	Lower center of gravity
Lighter	Heavier
Separate mounting needed	Integrated with frame

Notables

- The drive train is powered by eight Falcon 500 motors
- The drivetrain has PID control for position and velocity control, as well as a PID-based brake mode

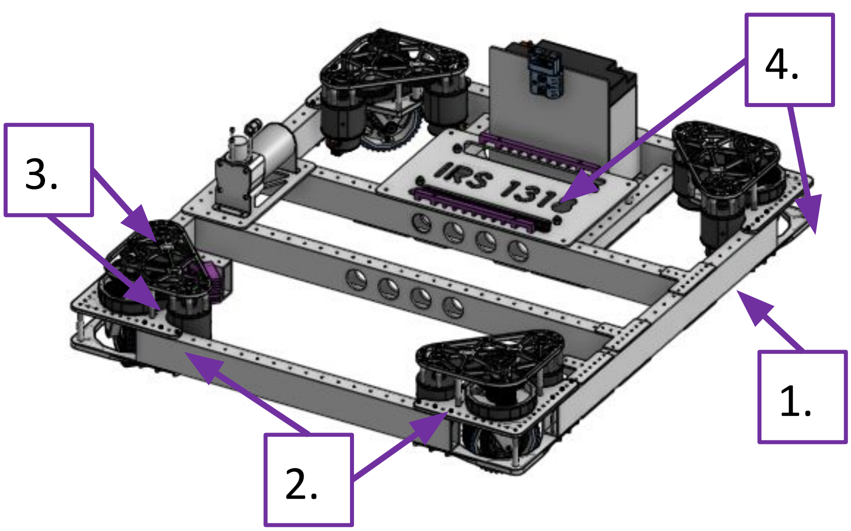
Hardware

Drive Train

Swerve Drive Train Design

The drive train this year is a 4-wheel swerve drive. It has 8 Falcon 500 motors coupled with a 6.75 : 1 gear ratio (about 16.3 feet/second max) within a SDS Swerve Drive Module.

The Final Product



Our modified VersaFrame Chassis

Parts:

1. VersaFrame 2x1.
2. 4 6.75 : 1 SDS Swerve Modules.
3. 8x Falcon 500 motors

Cargo System
Intake

Needs	Wants
Smoothly grab and transfer to Conveyor	Intaking with little driver accuracy
Limited jamming and easy way to remove jams	Intake easily while traveling at max speed
Easy way to accomplish ground pick-ups	

Possible Ideas

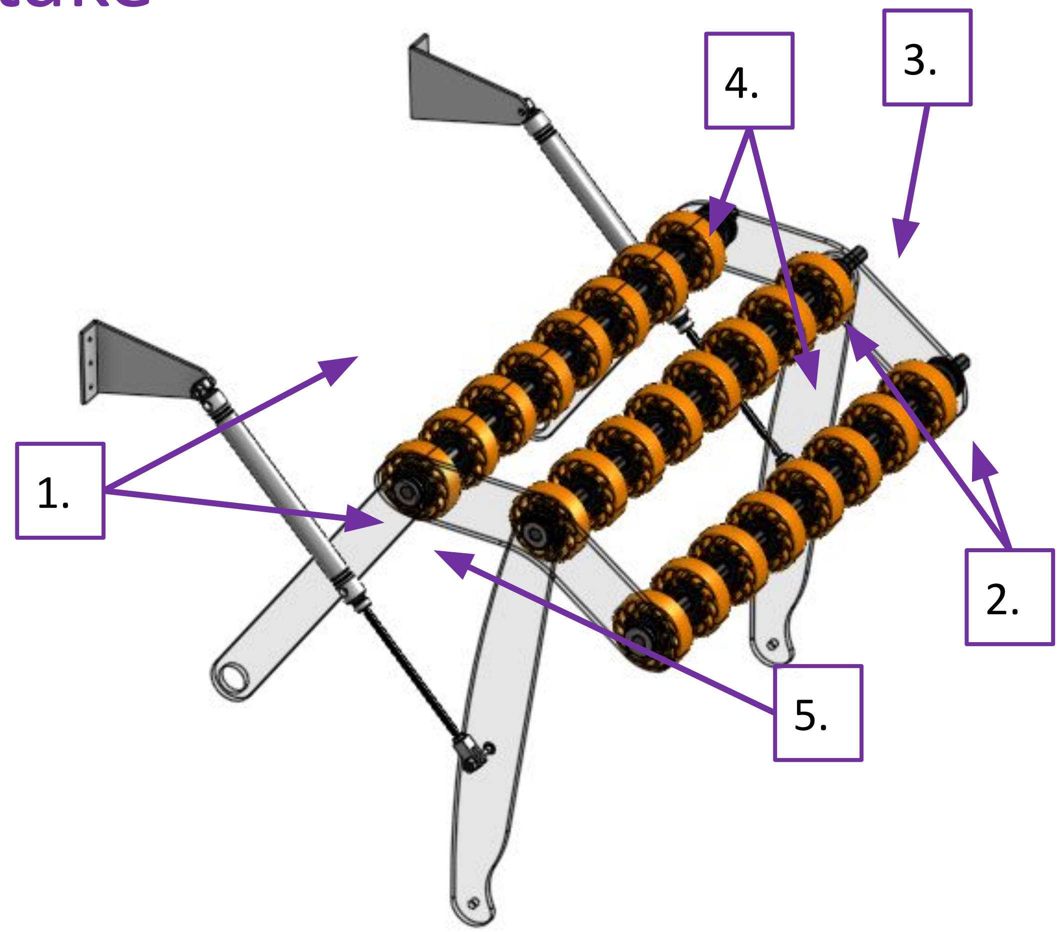
Through Bumper	Over Bumper
Possibly better grip on Cargo	Mechanically easier
Linkage dimensions smaller	Larger linkage
Mechanically difficult	Bumper better protects robot

Notables

- 3D printed 3” mecanum wheels center the Cargo before they enter the conveyor
- Large polycarbonate plates are machined

Cargo System

Intake



Our intake assembly

Features:

- Over-the-bumper power-cell intake
- Retractable
- 3D printed mecanum wheels

Parts

1. 4- 3” printed Mecanum wheels
2. BaneBots compressible wheels
3. Polycarbonate side plates
4. 2- 5” stroke pistons

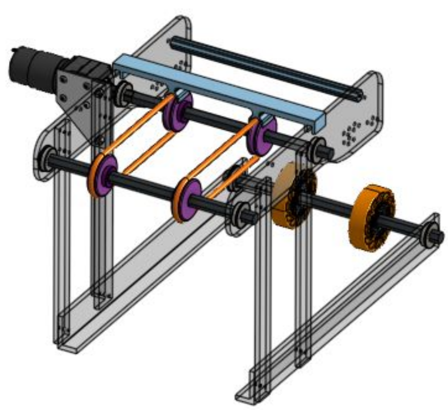
Cargo System

Conveyor

Needs	Wants
Securely store Cargo	
Pass through Cargo from the intake to the shooter.	Quickly transport Cargo to shooter

Possible Ideas

Conveyor	Indexer
• Simple • Transports Cargo quickly	• Overly complex • Slow



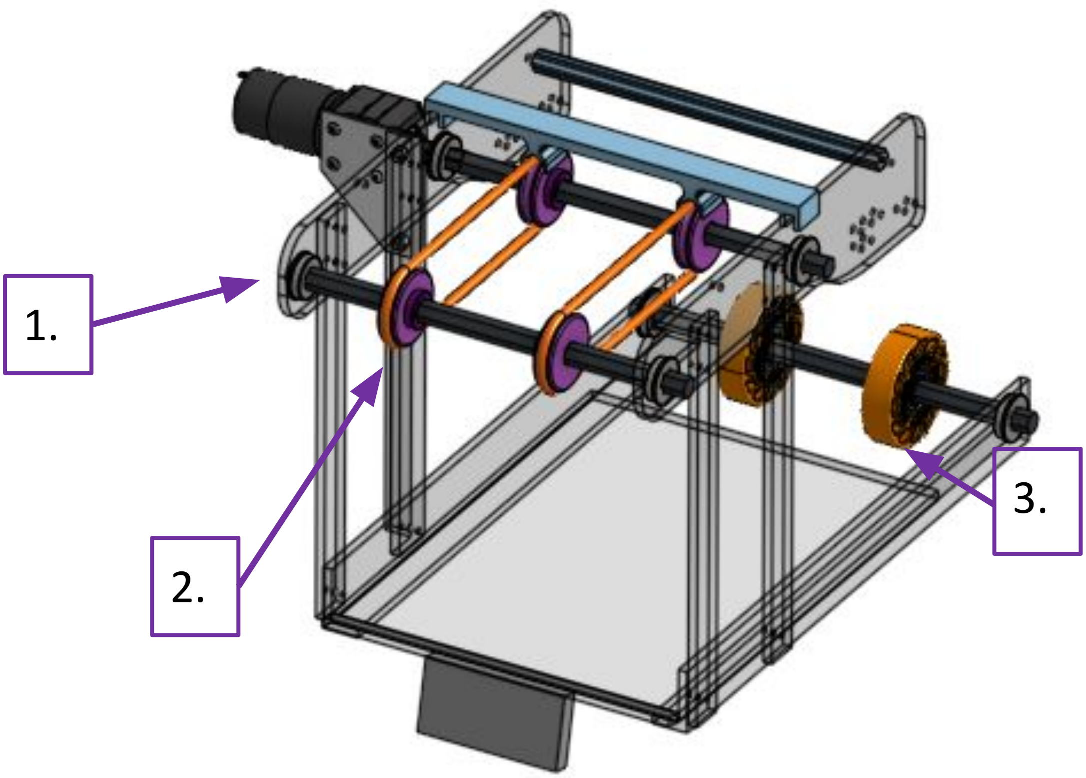
CAD model for our conveyor

Notables

- Contains 3D printed pulleys

Cargo System

Conveyor



Features:

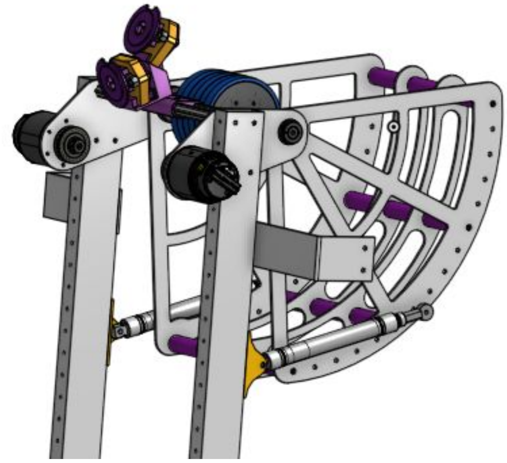
- A 775Pro motor with a 10 : 1 gear ratio
- 3D printed TPU pulleys
- Machined polycarbonate plates

Parts:

1. Polycarbonate side plate
2. TPU pulley
3. Compliant BaneBots wheel

Cargo System

Shooter



Needs	Wants
Ability to shoot Cargo into the upper hub	Ability to quickly shoot Cargo
Single shooting position	Multiple positions to shoot from

Possible Ideas

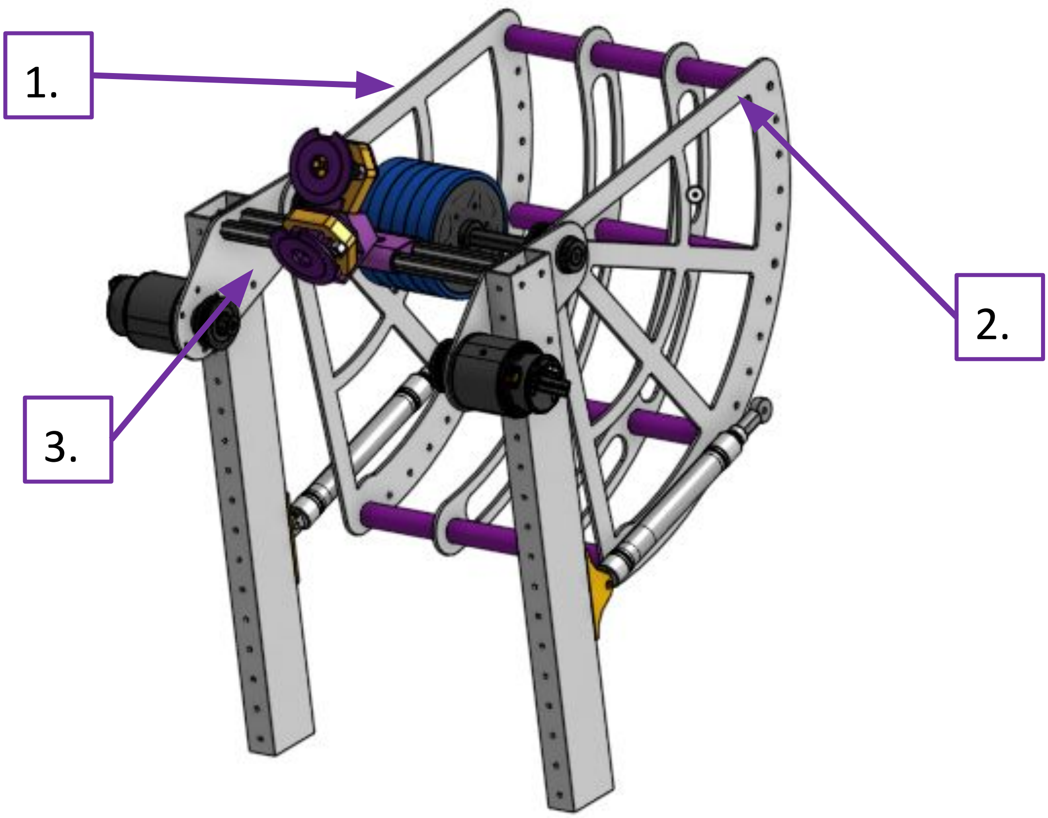
1 Piece Actuated Hood	2 Piece Hood
Pros	**Pros**
• Mechanically simple • With pneumatic actuation, can give multiple shooting angles	• Can shoot from multiple positions on the field • Mechanically more complex

Notables

- Retractable hood for a low profile
- Two Falcon 500 motors for faster and more powerful shots

Hardware

Shooter



Features:

- An actuated hood that allows for 4 different shooting angles.
- Two Falcon 500 motors for fast shooting.

Parts:

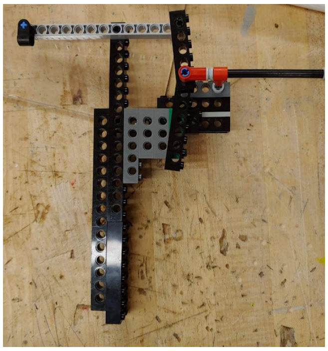
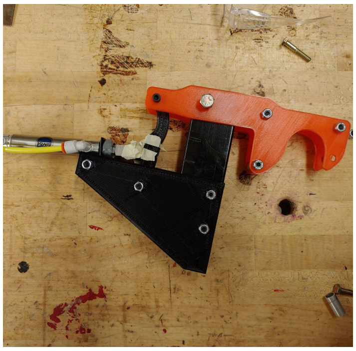
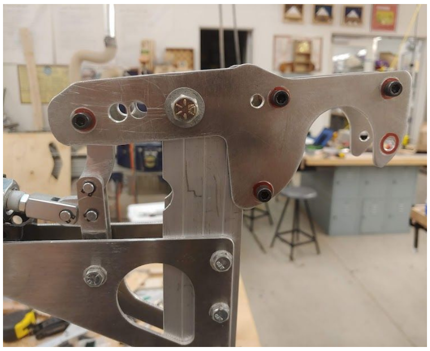
1. Machined aluminum hood
2. 3D printed PLA spacers
3. Two cameras

Hardware

Climber

Needs	Wants
Middle rung climb	Traversal rung climb
Able to climb in under 30 seconds	Light weight, space efficient

Hook closing and release ideas		
Piston	**Linkage**	**Over Center Linkage**
Piston used to swing hook off bar and make hook release bar. All weight on piston.	Piston actuated linkage used to move hook out of way - all robot weight on piston. May not release well under load.	Piston actuated over center linkage - when closed, default state remains closed. Releases under load.

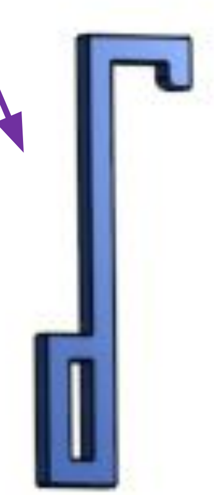




Prototyping process for the over center linkage climber design

Hardware

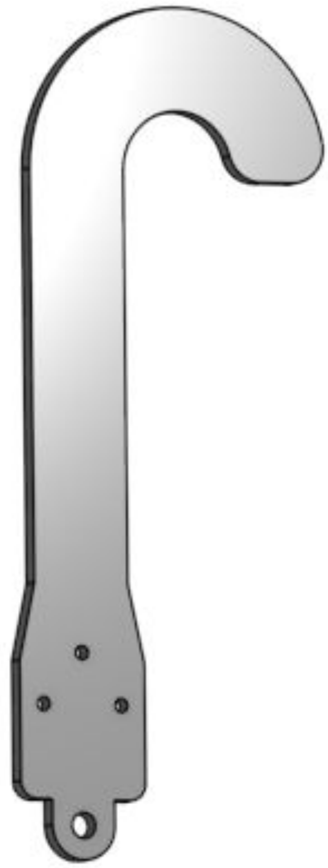
Climber

2.



3D printed hook holder

1.



CAD model of hook

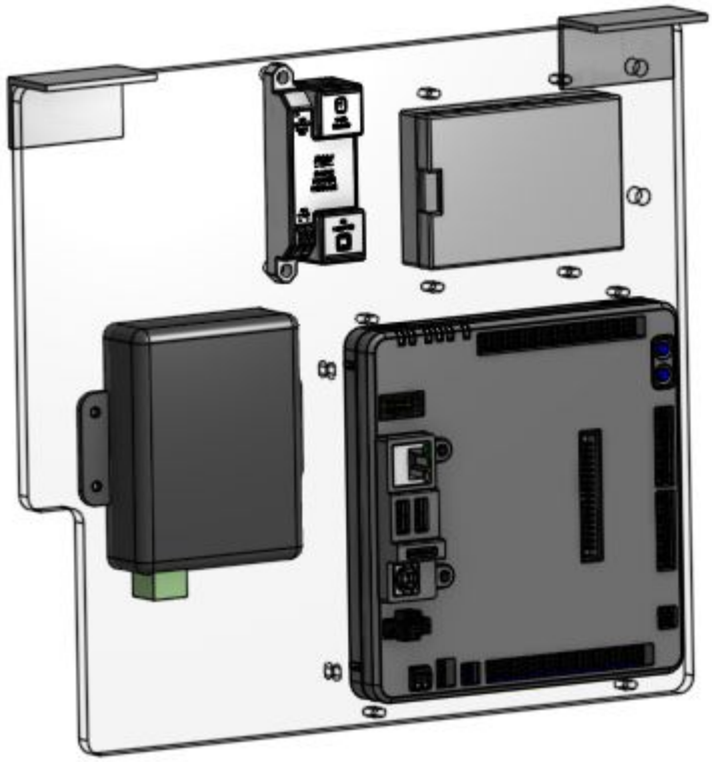
Features:

- 8” Piston extends hook to required height and provides lifting force
- Surgical tubing ensures vertical hook
- 3D printed TPU holding piece holds hook in place to stay within height limit
- Two polycarbonate hooks allow climbing to both the low and middle rungs

Parts:

1. Polycarbonate actuated hook
2. 3D printed hook holder

Electronics & Pneumatics



The left-side electrical board.

Electronics Notables:

- 2 main electrical boards
- PDH mounted under robot
- Electrical components mounted on mechanisms when possible to decrease complexity
- Dedicated/planned space for electronic systems based on CAD to integrate mechanical and electrical

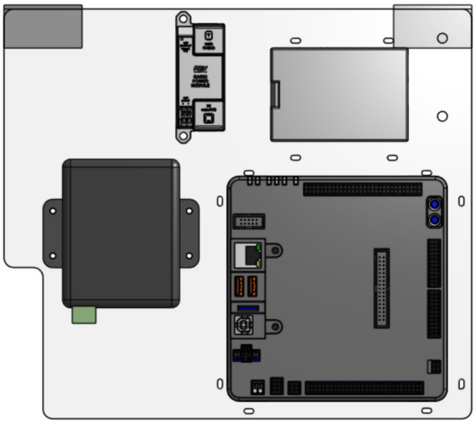
Electronics & Pneumatics

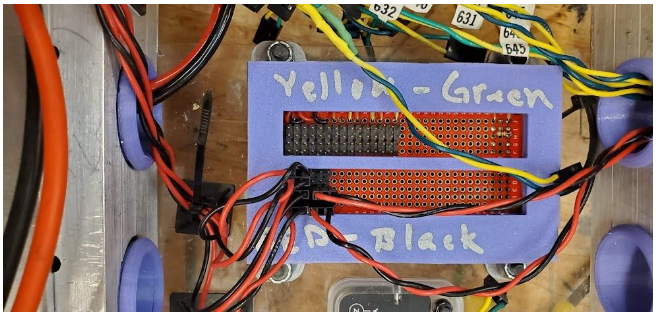
Left board	Right Board
Our left board contains the RoboRIO, Raspberry Pi, radio power module and ethernet switch. Located nearby are the VRM, Radio, and RSL.	The right board contains the Manifold and solenoids, the Pneumatics Hub, a circuit board to power the sensors and camera light rings, and pneumatic parts.

Other Electronics
PDH mounted on underside for easy access, CAN located nearby in a central location for ease of wiring, and motor controllers located near relevant motors.

<u>Pneumatic Notables</u>

- 1 Manifold, 5 solenoids
- Three air tanks, located under conveyor
- The ball manipulation system contains 4 pistons





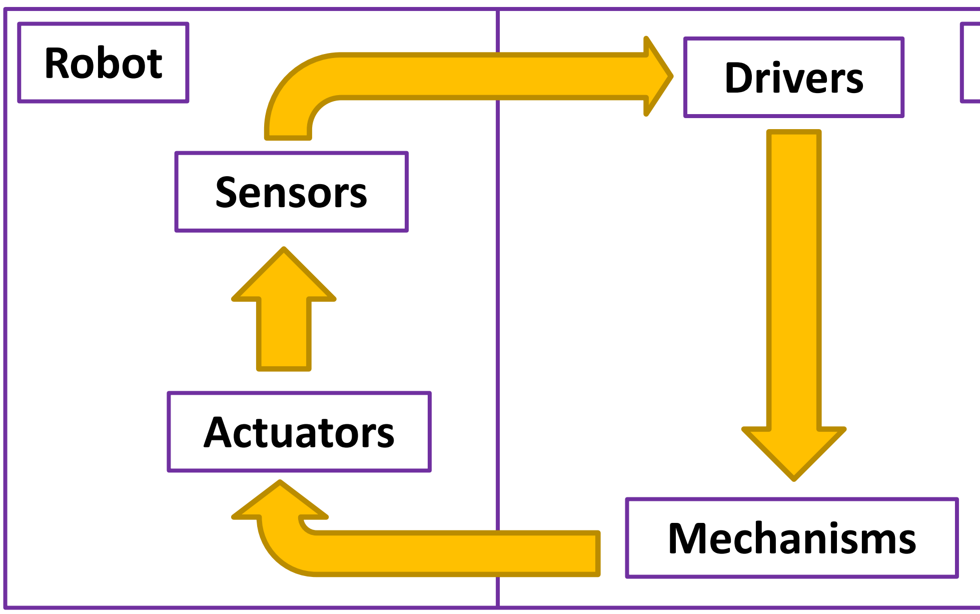
Software Architecture

Notables

- ✓ Macros
- ✓ PID feedback control
- ✓ Autonomous
- ✓ State machines
- ✓ Vision System

Dual input controllers with motion control

Our team uses Java for robot programming and utilizes Github as our source code repository.



A block diagram of our software architecture

Vision

Vision allows us to detect the retro reflective tape on the upper hub to align ourselves to be able to shoot cargo accurately. Since 2020, we have used vision on a Raspberry Pi instead of on the RoboRIO, which increases framerate. This year, we added vision tracking for cargo to aid during auto and teleop.

Software Architecture

Proportional Integral Derivative (PID)

- Velocity PID control allows us to regulate the velocity of the drivetrain to deal with inaccurate movement.
- Positional PID control gives us the ability to move our drivetrain to a specific position and maintain that position.

Smart Dash

Smart Dash receives information from the robot and displays selected data. This allows us to identify and/or solve problems more quickly.

Software Brakes

PID brakes to keep the robot still by fighting any opposing forces.

Swerve Drive

The swerve drive is controlled by kinematics and code we wrote and derived from scratch. We used linear algebra to calculate the angle and speed each of the modules needed to go to drive and rotate at a certain speed.
Using our own code instead of an external library allows us to have more control over possible maneuvers.

Scouting Network

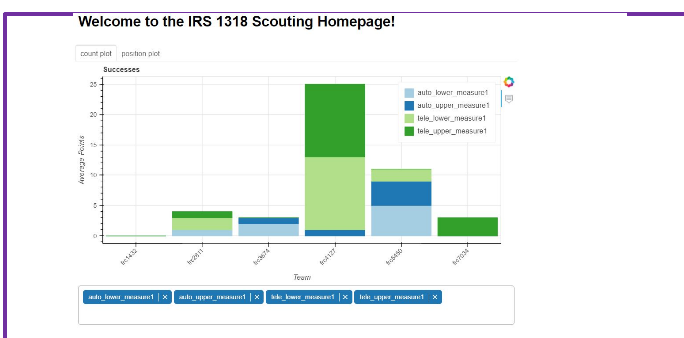
About

Our scouting network allows us to collect large amounts of data on the abilities of other robots. We then use this data in making better game strategies as well as for choosing teams during alliance selection.

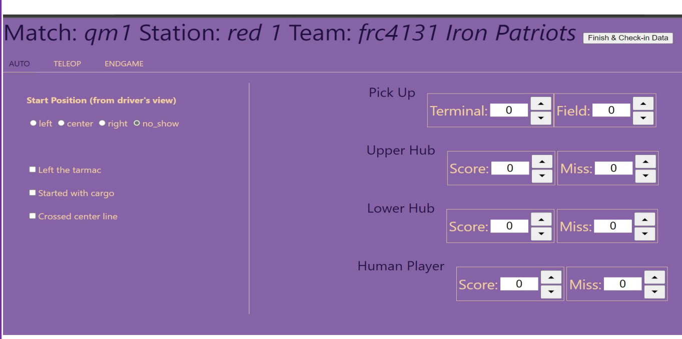
Programming

We have developed a web-based scouting platform that runs on a Flask WSGI server. Our user interface is coded using HTML, JavaScript, and CSS. We store scouting data in a SQL database through a Python server. We also use Bokeh, a python library, to create interactive visualizations in order to view and analyze our data.

Data Analysis



The Bokeh server for generating dynamic graphs



2022 UI Design for the Autonomous page of the Scouting System

Extras

The wood test rig and hangar we built

Fall Training

Before kickoff day students and mentors prepared for the build season ahead. Classes included electronics, data analysis, programming, and CAD.

Machining

We made many custom parts for our robot this year, out of both aluminum and polycarbonate. These were both designed and machined by our team and were used in almost every subassembly (intake, shooter, conveyor, etc.)

Field Pieces

To organize for the game without a field, we built various field pieces out of wood to practice with a more accurate representation of the field.

CAD

We use CAD to design parts and assemblies to make a completed robot model before its fabrication.

Thank you to all of our sponsors!