OPERATION TAC

TECHNOLOGY AND CHARACTER

FIRST ROBOTICS TEAM

FTC Team # 14295

"And whatever you do, whether in word or deed, do it all in the name of the Lord Jesus."

(Colossians 3:17)

Team Overview

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Our Mission: Learn TECHNOLOGY, Build CHARACTER

Our Passion: Share FIRST Programs Everywhere We Go!

Titus – 12th Grade

ROLES: Team Captain, Programming Lead, Robot Lead, Robot Builder, Video Editor, Driver
Successful contribution: Teaches teammates programming, electrical, mechanical, and CAD
"Teamwork helps everyone succeed."

Luke – 11th Grade

ROLES: Robot Builder Lead, Robot CAD Lead, Video Editor, Control Lead, Robot Design, Drive
Successful contribution: Teaches teammates how to CAD and 3D print custom parts for robot
"Teamwork facilitates idea generation."

Hannah – 9th Grade

ROLES: Engineering Portfolio Lead, Builder, Programmer, Social Media, Robot Coach
Successful contribution: Teaches teammates how to manage team goals and team plans
"Teamwork cultivates relationships."

Mr. Jason Rehard

Head Coach
"Teamwork makes synergy possible."

Maddox – 12th Grade

ROLES: Robot Builder, Robot Designer, Team Build Lead, Robot Part Manufacturer, Outreach
Successful contribution: Teaches teammates how to design and manufacture robot parts
"Teamwork increases innovation."

Tojo – 10th Grade

ROLES: Robot Builder, Fundraising, Outreach, Sponsorship, Engineering Notebook Document
Successful contribution: Helps teammates by acquiring STEM mentors and sponsorships
"Teamwork increases productivity."

Elizabeth – 7th Grade

ROLES: Engineering Portfolio, Photographer, Video Edit, Outreach, Programming Apprentice
Successful contribution: Helps teammates by document journey and assisting programmer
"Teamwork inspires learning."

Mrs. Erin Rehard

Assistant Coach
"Teamwork boosts morale."

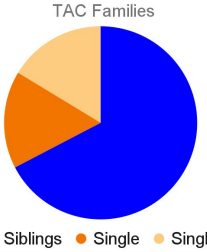
Proudest Accomplishments

- Learned **Odometry** using RoadRunner
- Gained **two new teammates** - Tojo and Elizabeth
- Acquired a **NASA** engineer early on as a STEM mentor
- Acquired a **MIT** engineer early on as a STEM mentor
- Acquired a **Raytheon** engineer as a STEM mentor
- Acquired a **Boston Dynamics** engineer for assistance
- Received sponsorship from **Lowes** - parts and tools
- Received sponsorship from **Micro Center** - 3D printer
- Received sponsorship from **Chick-fil-A** - scrimmage lunch
- Received sponsorship from **Applied Medical**
- Demonstrated our robot to 60 kids at **Academic Chess**
- Demonstrated our robot to 50 kids in an **AWANA** youth club
- **Set up one and hosted two scrimmages** with other teams
- Taught a Lego Engineering **Robotics Workshop**
- Earned the **highest score (286 points)** in the qualifier
- Earned the **highest score (288 points)** in the championship

Gracious Professionalism

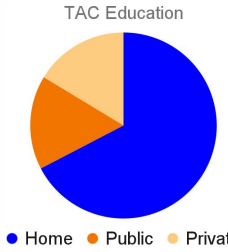
***FIRST* Programs changed our lives** by instilling in us Gracious Professionalism - a wise use of time during our childhood. We are better people because of *FIRST.* **The massive impact *FIRST* has on us** inspires us to take the initiative to seize every opportunity to share about *FIRST* everywhere we go. Thank you, *FIRST!*

TAC Tidbits



Four out of the six teammates are all **siblings**!

Can you guess which ones?



Four out of the six teammates are all homeschooled; one public school; one private school

Team Plan

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SMART is a well-established tool that we use to plan and achieve our goals.

S Specific | M Measurable | A Attainable | R Realistic | T Time-bound

Goal Setting Provides:
- Motivation and Prioritization
- A Realistic Timeline
- Inspiration for the Future
- Clarity to Decision Making

Business Goals

1. Reduce production expenses by 5% over the course of the season and reuse parts
2. Increase the total sponsorship of our team by 10% over the course of the season
3. Research ways to use a non-profit organization for large company donations

How will we measure success? If we've learned technology & grown in character.
What do we hope to learn by being a part of this team? Teamwork and inclusion.
What makes our team unique? Everything we do, we do it for the glory of God.

Outreach Goals

1. **Share FIRST everywhere!**
2. Accomplish one general outreach event per month
3. Acquire one STEM mentor or advisor per month
4. After Meet 0, increase both outreaches with robot
5. Utilize Zoom and FaceTime meetings to expand reach
6. Help FTC teams on discord

Sustainability and Recruitment Goals

1. Always have a middle schooler on the team
2. Maintain relationship with previous teammates
3. Maintain relationship with previous sponsors
4. Actively attract students by telling friends what FIRST is & how FIRST has changed our lives.
5. Contact homeschool Co-Ops for recruitment
6. Recruit for FTC & FLL through outreach events

Letting the world see our PASSION for FIRST is the key to sustainability and recruitment!

Cultural = TAC preserves a Christian heritage, building a faithful legacy
Social = TAC includes all teammates
Economic = TAC reuses robot parts
Environment = TAC maintains a healthy robotic lab workspace

Marketing and Fundraising Goals

1. Increase website traffic by giving business cards
2. Gain social media followers by regular postings
3. Raise TAC brand awareness via shirts & media
4. Grow a phone and email list with contact details

Product: FIRST Programs
Target: Everyone
Message: Inspire people through FIRST
Mediums: In person, online, social media, print

Budget

Goal to raise $5,610 for:
- **Registration ($850)**
- **Robot Parts ($2,780)**
- **Robot Tools ($1,910)**
- **Miscellaneous ($670)**

Goal met and exceeded:
- **$6,530 raised**
- **[$320 surplus]**

Our Purpose for Community Service: Invest in our local community by using our skills to help others succeed


Serve on church Tech Team


Serve on church facilities team


Serve on church refreshment team


Serve as leaders in kids Bible camp


Lead children's worship & choir

Help Operation Christmas Child

Team Strategy

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Our Goal: To be a WORLD RECORD ROBOT, so we keep pace with the WORLD RECORD SCORES.

Robot Game Strategy

• Be able to go **around & over barricades**	• Intake freight **fast** while only controlling one at a time
• Place freight on **all three tiers** of the Shipping Hub	• Use and **detect our TSE** in the Autonomous
• Complete **three cycles** to the Shipping Hub in Auto	• Be able to **deploy ten ducks** in endgame
• **Cap both TSEs** & park in Warehouse in Endgame	• **Partner** with teams who put freight on Shared Hub

Robot Game Breakdown

Goal	Description	Points
Auto 1	Detect location of TSE & deliver pre-load box	20+6=26 points
Auto 2	Complete 3 cycles (warehouse, freight, delivery)	3x6=18 points
Auto 3	Park completely in warehouse	10 points
Teleop 1	Place 10 freight on top tier (8 sec per cycle)	10x6=60 points + auto freight 4x6=24 points
Teleop 2	Deploy 9 ducks while double capping TSE	54+30=120 points
Teleop 3	Park completely in warehouse	6 points

Total [including points from a **weak partner** (nothing scored by them)]: **228 points**
Total [including points from a **good partner** (6 Shared Hub cycles in 120 seconds)]: 228 + 78 = **306 points**
Total [including points from a **strong partner** (12 Shared Hub cycles in 120 seconds)]: 228 + 122 = **350 points**

Development of New Skills

- **Odometry** - watched Road Runner tutorial
- **Java** - took Pluralsight Java programming course
- **Clean Coding** - read "Java for FTC"
- **CAD** - using Fusion 360 tutorials
- **3D Rendering** - using Fusion 360
- **Video Animation** - read "Stop Motion Explosion"
- **Video Editor** - taught by team member
- **Premiere Pro** - trained by employer
- **Photoshop** - taught by team member
- **Illustrator** - watched YouTube's course
- **Google Slides** - trial and error
- **WordPress** - online instruction and videos

Greatest Challenges

1. **Our assistant coach broke her neck** - it was mentally difficult to continue with the season
2. Competing as a community team - we do not have school funding or access to school resources

Lessons Learned

- **Take risks** but ask for help to avoid costly mistakes
- When building a robot, **start small** then expand
- **Strategically wire** the robot for easy access
- When 3D printing, **check often for accuracy**
- **Do not use locktite** on any kind of plastic

16 General Outreach

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Our Purpose for General Outreach: Promote FIRST, Acquire Team Members, Gain Sponsors

October 6, 2021 **AWANA Program**
Proud accomplishment - We led Robot Night with 50 kids in AWANA program. We created a game of previous field elements and kids drove our robot!
Outcome: Student awareness of FIRST

February 16, 2022 **Lego Engineering Class**
Proud accomplishment - kids signed up for our Lego Engineering Robotics Class. We taught them naming schemes, different support structures, and had them build!
Outcome: Recruited 4 kids for next year

February 26, 2022 **Pacific Coast Church**
Proud accomplishment - We advertised in the local newspaper an FTC scrimmage demonstration. Forty people from the local community attended to learn about FIRST.
Outcome: Public awareness of FIRST

March 4, 2022 **Academic Chess**
Proud accomplishment - At a Friday night chess club, we demonstrated our robot to the 60 kids there. Some students showed interest in joining FLL and FTC next year.
Outcome: Possible recruitment

August 23, 2021 **iLEAD Exploration**
We shared about FIRST, FTC, our team, and our robot to iLead Exploration, a homeschool charter school. We were able to explain and demonstrate our drive base.
Outcome: Awareness

September 11, 2021 **Home Health Care**
After sharing FIRST and demonstrating our robot with Home Health Care, one therapist told her son about us. We then set up a meeting time for them to come again.
Outcome: Recruitment of 1 student

December 4, 2021 **Walmart**
We went to Walmart to ask for sponsorship. We shared FIRST, our team, and our robot with them. They were super impressed and told us how to get sponsored.
Outcome: Awareness of FIRST Programs

December 7, 2021 **Heritage Christian School**
Members of this homeschool group came to our FTC lab and we showed the robot, explained the season's challenge, and promoted involvement in FIRST and TAC.
Outcome: Potential recruitment

January 31, 2022 **SC Christian School**
We shared FIRST with a new teacher and she asked us to help in her STEM class. We provide mentorship and materials.
Outcome: Mentorship and awareness

February 2, 2022 **SCOR Physical Therapy**
After sharing FIRST, our team, and our robot, we a with them, we asked them if they would sponsor us.
Outcome: Potential sponsorship

February 9, 2022 **Newspaper**
The Dana Point Times featured Operation T.A.C. because we broke the state record for highest score in an in-person meet.
Outcome: Attendance at demonstration

February 15, 2022 **Harvard Business School**
After Mr. Lem told told them about us, a blurb about our team and robot made it into the Harvard Business School Bulletin.
Outcome: Awareness of FIRST, FTC, TAC

February 14, 2022 **Sendero Park**
After demonstrating our robot to kids at a park, we told them about the Intro to Lego Engineering class we were hosting.
Outcome: Recruitment

February 14, 2022 **HCS Co-Op**
Although a fellow schoolmate is moving to Florida, we told him about FIRST so that he can join a team in Florida.
Outcome: Recruitment for FTC in Florida

February 16, 2022 **Neighbors**
After telling our neighbors and community about FIRST and our team, several kids want to be on our next FLL and FTC team!
Outcome: Recruitment

February 22, 2022 **Newspaper**
We were in the San Clemente Times calendar section, inviting the general public an invitation to our scrimmage at PCC.
Outcome: Attendance at demonstration

20 STEM Mentors

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Our Purpose for STEM Outreach: Promote FIRST, Acquire Mentors, Gain Knowledge

Ira Siegelman
Manager
NASA

September 9, 2021 **We acquired a mentor** while demonstrating our robot inside Lowe's. **We learned** how to correctly wire our robot, be open about our past failures, and to keep our first designs simple until we have the general idea for what we want for our robot. **Proud accomplishment** to have a NASA engineer help encourage us every week!.

September 9, 2021 **We acquired a mentor** because he is a friend of our mentor, Mr. Ira. **We learned** to make our robot base free from any weak spot. He showed us how to identify weaknesses and advised us on how to fix it. He attends meetings and meets. **Proud accomplishment** to received quality mentorship from one so skilled in STEM.

Len Kranser
Mechanical Engineer
MIT

Megan Schneider
Coordinator
Applied Medical

October 12, 2021 **We acquired the mentor** because Code Orange, FRC introduced us. **We learned** that it pays to be patient and persistent when trying to acquire mentors and sponsorship from large organizations. **Proud accomplishment** since we worked so hard for many months with this mentor to secure Applied Medical as a sponsor.

October 30, 2021 **We acquired the mentor** she is part of some of the teammate's family. **We learned** to find the optimal autonomous path for a shorter cycle time in autonomous. We learned not to tighten our wires at 90°. **Proud accomplishment** because we have a mentor from Raytheon who truly saved us from several massive electrical errors.

Alison Shah
Electrical Engineer
Raytheon Technologies

Adam Brody
STEM Teacher
Strategic Kids

November 12, 2021 **We acquired a mentor** because he is a friend of some of our team. **We learned** how to effectively teach kids engineering with legos. In order to keep a child interested in what we are teaching them, we need to make the class very fun, energetic, and a hands-on experience.

January 22, 2022 **We acquired the mentor** through a teammate's connection with 3M. **We learned** presentation skills while we were presenting and explaining our robot. By asking us questions, we were able to see if what we were saying was clear, concise, and detailed to the receiver.

Dave Scarponi
Mechanical Engineer
3M

Anthony Cilento
Mechanical Engineering
Carrier ENT.

January 25, 2022 **We acquired the mentor** by being introduced to a teammate's friend. **We learned** how to present ourselves in an professional way at the competitions to the judges and to other teams. He strongly advised us to have everyone on the team talk while sharing our team with the judges.

January 25, 2022 **We acquired the mentor** by being introduced to a teammate's friend. **We learned** to make sure that everyone on our team speaks while we share about our team to the judges, other teams, and other mentors. He also advised us to find a way to increase our robot's speed and precision.

EJ Johnson
Program Manager
Equifax

Don Kidd
IT Engineer
Miami University

January 27, 2022 **We acquired the mentor** through a connection from Miami University. **We learned** to find out a way to add a light color sensor to our robot which will flash to tell us what block type we have in our robot at that time. He was super encouraging and told us that he loved what we were doing as a team on our robot.

January 27, 2022 **We acquired the mentor** through a teammate's parents connection. **We learned** to consciously make sure that not just one person speaks while explaining our team and our robot but everyone on the team. To make that happen, everyone on the team must be educated about all of the aspects of the team.

Andrei Dokukin
Psychiatrist
St. Mary's Hospital

Doug Hamrin
Engineer
URSA Energy Solutions, Inc.

January 27, 2022 **We acquired the mentor** through a teammate's connect from URSA. **We learned** to present our team in a clear, concise, yet detailed manner to the judges. To make that happen, everyone on the team must be regularly educated about the robot and the team aspects regardless of their specific contribution to the team.

January 30, 2022 **We acquired the mentor** through our teammate's family connection. **We learned** a way to troubleshoot some of our robot path problems in autonomous. He loved what we were doing and came saw our robot again. He also told us that the new skills we were learning would provide great use in the engineering world.

Gary Ballance
Hardware Engineering
TradeStation

20 STEM Mentors & 2 Assists

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Mick Haupt
Graphic Design
CRU

January 31, 2022 **We acquired the mentor** because he is s friend of the Head Coach. **We learned** how to professionally organize our portfolio by staying very simple in our descriptions. This is so the judges can easily see the main points in a clear manner.

February 1, 2022 **We acquired the mentor** when he came to bring our coach dinner. **We learned** how to think more creatively in regard to our cosmetic aspects of our robot. He added that we might want to add lights to our robot, one thing we wanted to do.

Tom Benge
Senior Analyst
Mem. Care

John Rehard
Research Scientist
KC University

February 2, 2022 **We acquired this mentor** because he's an uncle of a some members. **We learned** ways to make sure that we did not have any loose screws on our robot. He also advised us to put videos on our website so that others can see what we are doing.

February 6, 2022 **We acquired the mentor** because some of our team works for him. **We learned** how to make the audio for our compass video high quality and professional by correctly mixing the audio and tellings us to make some pictures move for effect.

Ron Alayra
Tech Director
Pacific Coast Church

John Ballance
Dir. of Eng.
SoCal Edison

February 7, 2022 **We acquired the mentor** through our teammate's family connection. **We learned** how to wire our robot for our capping and duck-grabbing mechanism. He also pointed us in the right direction for the mechanism while we were still formulating it.

February 11, 2021 **We acquired the mentor** because he is a friend to some of our team. **We learned** how to portray our team in a professional, confident, and engaging way when we share with the judges our five minute presentation.

Derek Sommerville
Audio Dir.
The Relay

Peter Selby
Phys. Teach.
CDM HS

February 11, 2022 **We acquired the mentor** since he is related to one of our teammates. **We learned** how to answer the questions in the Q & A section of our judging time. He also mentored us in how to make the design process for our team.

March 1, 2022 **We received assistance** by calling the Boston Dynamics receptionist. **We learned** to think outside the box in regard to alternatives to tape measures. **Proud accomplishment** for us to get our foot in the door of Boston Dynamics!

Linda Relson
Mech. Eng.
Boston Dynamics

Ethan Reyes
Cust. Svc.
Micro Center

March 4, 2022 **We acquired the mentor** when we needed to replace our 3D printer. **We learned** many new capabilities we could do with CAD and 3D printing components. **Proud accomplishment** for us to have our 3D printer sponsored by Micro Center.

March 4, 2022 **We received assistance** by going shopping for a newer 3D printer. **We learned** to expand our options and think in new ways. They advised how to fix our broken Ender 5 Pro by telling us to get a new driver for the main printer screen.

Justin Loes
Tech Associate
Matterhackers

Serving FIRST

Our Purpose for Connecting with the FIRST Community: Build Relationships, Assist Teams, Have FUN!

Help League 01 Meets 0-3
We arrive early and stay late to serve our own league.

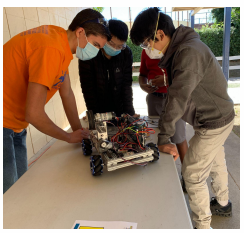
Help League 02 Meet 0
This is a new league so we helped train the volunteers.

Host Scrimmage
Held practice matches with BrainStormz & 2nd Rebellion.

Help Set-Up Qualifier #1
Volunteered to help SoCal FTC set-up the first qualifier.

Set Up & Host Scrimmage
Matches with BrainStormz, iBOTZ, and 2nd Rebellion

Assist Teams on Discord
Help answer questions on 3 different FTC discord channels.

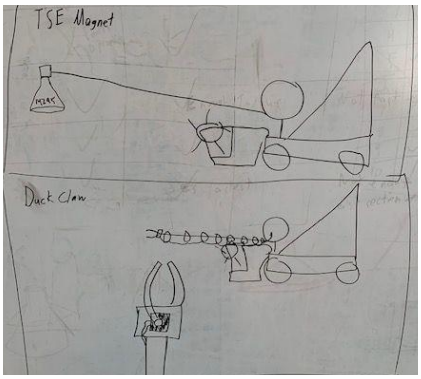

Our Design Process

STEP 1 - Identify the problem we're trying to solve
STEP 2 - Brainstorm and explore solutions
STEP 3 - Prototype with cardboard
STEP 4 - Design with CAD
STEP 5 - Test and improve our designs for ability, speed, and accuracy

We take these steps before we print 3D parts and before we buy components so that we don't waste **time and money** making any careless mistakes.

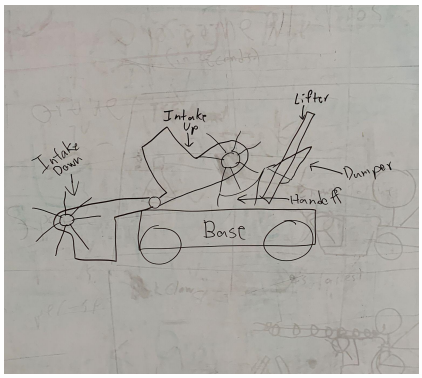
STEP 1: Identify the Problem - Robot Design Strategy

Drivetrain	Drive over the barricades without getting stuck by making our polycarbonate base panels curved
Intake	Suck in every kind of freight with a vacuum like mechanism rather than a grabber arm
Lifter	Lift the dumper to any Alliance Hub level by using a stringed lifter system
Dumper	Dump the freight without much friction by putting more ribs into the dumper
Capping	Cap our TSE and our alliance's TSE by using a magnetic, extendable tape measure
TSE	Make the TSE magnetic so that the capping mechanism can easily find the TSE
Duck Spinner	Spin ducks with only one spinner by making the spinner removable depending on the alliance



STEP 2: Brainstorm and Explore

Utilizing our creativity to brainstorm ideas is one of the most rewarding aspects of the design process. Before we CADed, purchased, or built anything, we, together as a team, thought through all of the possible options before we made a decision. This helped us narrow down what options would work with our strategy and what would not work.



STEP 3: Prototype

Once we had a general idea of what possible ideas could work, we started prototyping with cardboard to see what the best prototype there was.

STEP 4: Design with CAD

Then we started CADing our design. This greatly helped us not to waste time, energy, and money on careless mistakes that could easily be avoided.

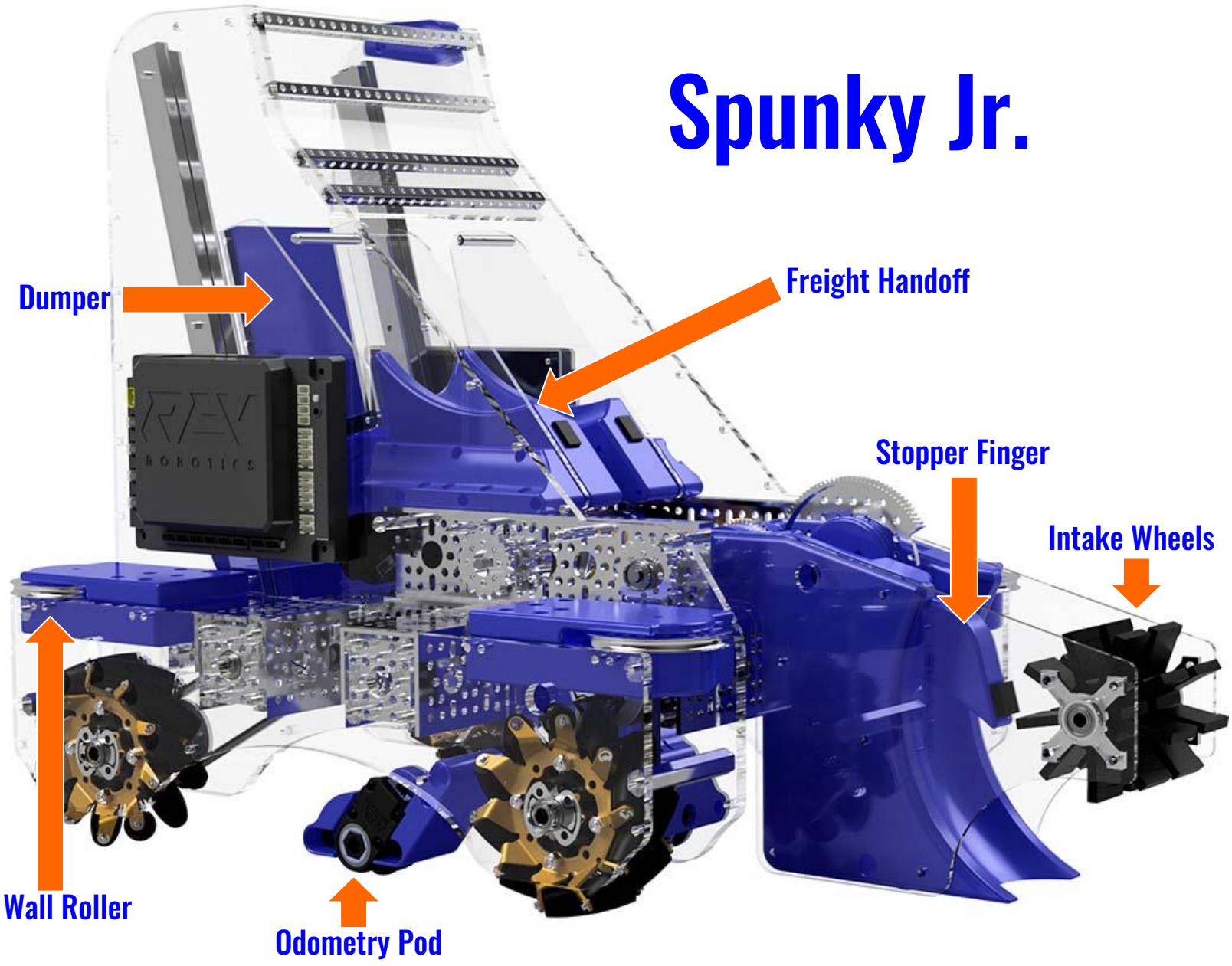
STEP 5: Test and Improve

We **iterate** our design to refine our robot. We always are on the lookout for something that needs to get fixed or improved. For example, we rebuilt the base 3 times, the handoff 3 times, the duck spinner 3 times, the intake 4 times, the dumper 4 times, and the capping mechanism 4 times. We have **160** printed CAD parts, including iterations. For the protective side panels, we began with plexiglass but after multiple problems, we now use **polycarbonate** because it provides strong but light structure, great visibility, and **amazing** aesthetics!

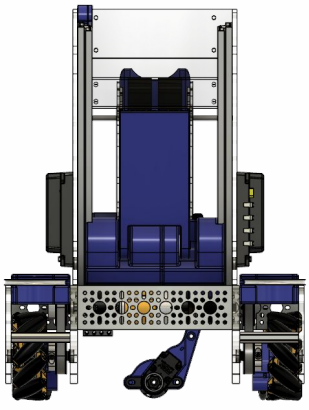
Driver's Station Design

After accidentally dropping our driver's station, we decided that making a drivers station was better than caring the remotes and driver hub separately because we could easily lose them. We 3D printed our team numbers on for effect.

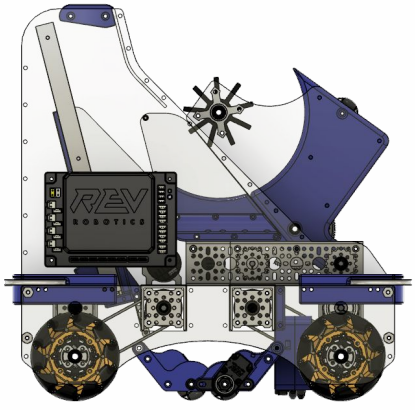
Spunky Jr.



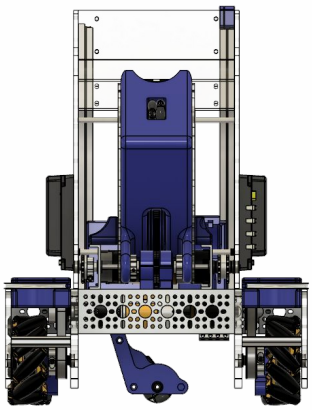
Back View



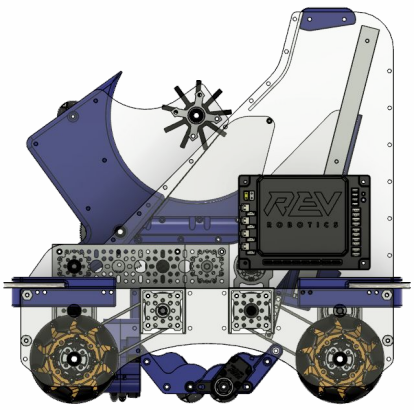
Right View



Front View



Left View



Drivetrain

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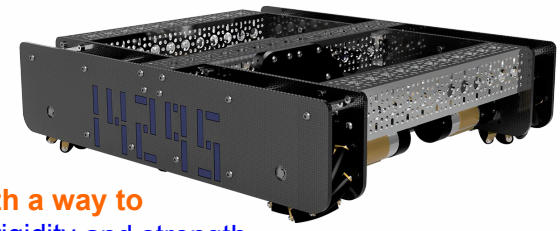
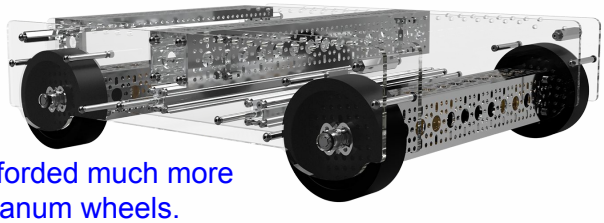
8/12/2021 - 9/20/2021



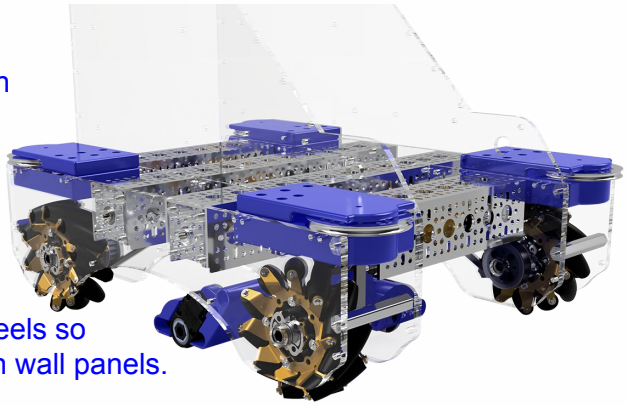
#1 - Trying to get ahead of the game, we designed our first base before the game reveal. We did not count on there being terrain on the field however, so this base was never built. Our original design used carbon fiber because of its low weight and high strength. This base had odometry pods built in. Instead of the normal four-panel base design with structure spanning the inner two plates and the outer to inner plates, **we came up with a way to have channels spanning the outside plates.** This dramatically increases rigidity and strength.

9/18/2021 - 12/2/2021

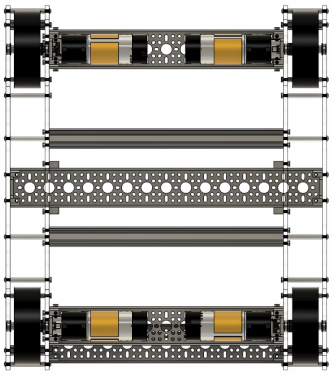


#2 - We did not want to bevel gear our drive motors since we had bad experiences with that last year, so we decided to focus on driving over the barricades. With this strategy, we removed the odometry pods and gave our base clearance. We also decided to use Plexiglass for the base since it was much more affordable than carbon fiber, easier to cut, and afforded much more vizability. We thought about using Rhino wheels, but ended up using Mecanum wheels.

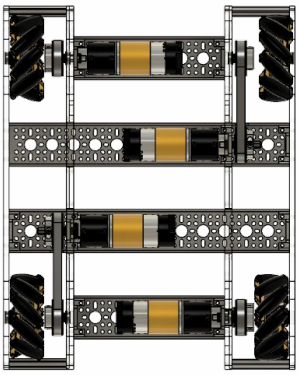
11/23/2021 →



#3 - After Meet 0, we knew that we would have to redesign our robot in order to be competitive at the higher levels. Because we wasted so much time traveling over the barricades, we knew that we had to make our robot narrower. We also kept hitting the shared shipping hub, so we had to make our robot shorter. Also, we gave our robot much more clearance so that we could not get stuck on the barricade spike. Knowing that autonomous is a huge component to success, **we designed and installed odometry pods that could be lifted out of the way** after autonomous. We equipped our robot with wall roller wheels so that it could roll along the wall and not get caught on the spaces between wall panels.

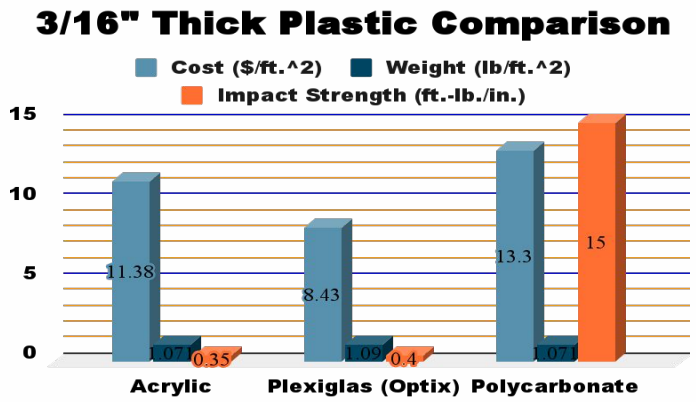


Direct Drive Motors



Belted Overlapping Motors

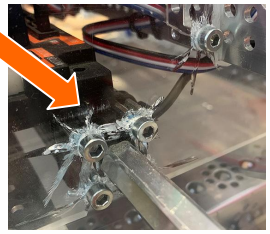
The first two robot drivetrains utilized a direct drive motor method. This allowed the motors with long shafts to be directly attached through radial and thrust ball bearings to the wheel clamping hubs - attaching the wheels very securely. However, because the motors were located end to end, the robot was too wide to fit between the barricade and the wall. That is one of the main reasons for the new robot. Because we did not want bevel gears, **we invented an alternating belted motor design** allowing the motors to overlap and the robot to be narrower.



We originally used Plexiglass on our robot, but after doing research, we found that polycarbonate is stronger.

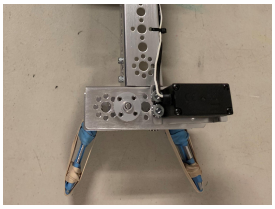
Plastic Problems

DON'T USE LOCTITE NEAR PLASTIC!!! We made this mistake right before Meet 0, and our Plexiglass inner base panels were destroyed. They had to be remade.



Intake

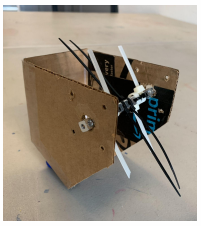
OPERATION TAC 14295



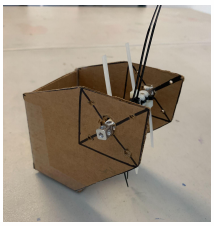
Intake Body Iterations

#1 We tried a grabber arm, but we soon realized that it would be very difficult to line up. We needed something faster.

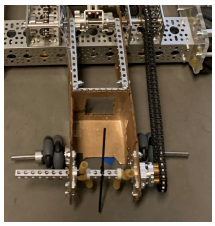
#2 We tried prototyping an intake with an angled bottom, but the freight would slide out.



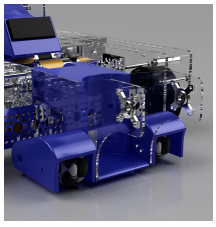
#3 We made a fairly similar design to #2 but with a flat bottom, and we liked it.



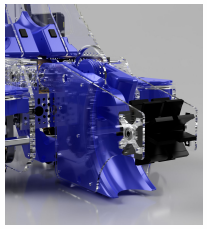
#4 Prototype #3 had no way to be mounted, so we made a larger version with omni wheels.



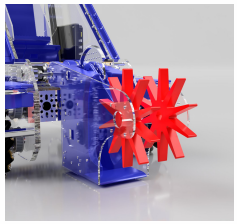
#5 We tweaked and designed and printed our intake with polycarbonate sides.



#6 We added a stopper finger, embedded the omni wheel, and curved the slope.

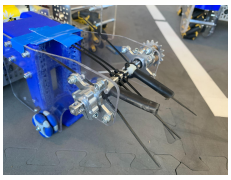


#7 We embedded a color/distance sensor, reverted to a flat bottom, added side intake wheels.

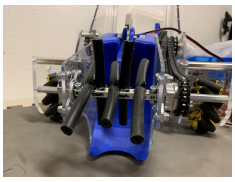


Intake Beaterbar Iterations

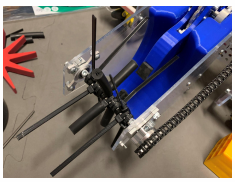
#1 We used zip ties for the first intake, but they did not give enough grip, so we attached surgical tubing to some of them.



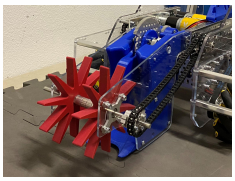
#2 After switching to intake #6, we tried to fix the grip problems with our first intakes. We attached lengths of surgical tubing to a beam frame, but the tubing was not grippy enough or rigid enough. It bent too close to the bar.



#3 We tried thicker surgical tubing coving short zip ties for intaking the ball and cube while long zip ties beat the duck into the intake. This design was better than the previous two, but it still didn't pick things up fast enough.

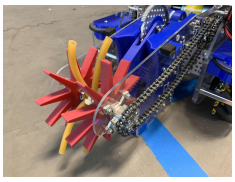


#4 Grip is constantly our problem. The first three beaterbars did not have enough. As it turns out, the entraption stars had way too much! They would intake so hard that our intake would seize. We had to reduce the grip.



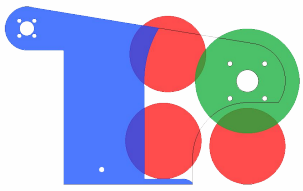
#5 For this intake, we used long zip ties for beating the duck into the intake, and we used a large cut gecko wheel for intaking the larger freight. It still was not grippy enough, and it had a hard time intaking the ball.

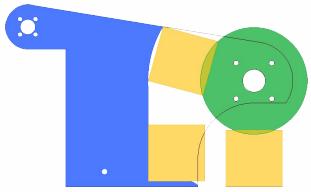
#6 Our latest intake uses entraptions stars for grip and side-spinning boot wheels as a motorized funnel. This solves the problem of shoving the ball out of the intake instead of picking it up. Success!



Intake Corner Design

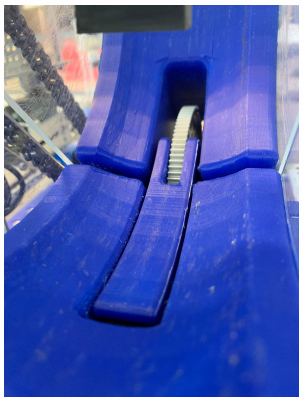
Our latest intake uses geometry to reduce the risk of jamming the intake. **We realized that if a circle is drawn in the center of a square, there are vacancies in the corners.** We used this fact when designing our current intake. As shown in the drawings, the balls and cubes touch the intake wheel when entering and exiting the intake, but they can rest in the corner as the intake spins without jamming the intake.





Drawing Legend

- Intake Body
- Intake Wheel
- Ball
- Cube



Intake Finger Stopper

While using intake #5 (the intake on Spunky), we kept kicking the freight out of our intake. Because we are trying to cycle as fast as possible, we want to intake as fast as possible. Obviously, we waste time if we keep throwing our freight out of our intake. To solve this problem, **we invented the intake finger stopper**. This is a geared finger that blocks freight from coming out the top of the intake while it is down, but easily folds into the next slope when the intake is up. Our stopper finger is purely mechanical, and it requires no electronics at all!

Lifter & Dumper

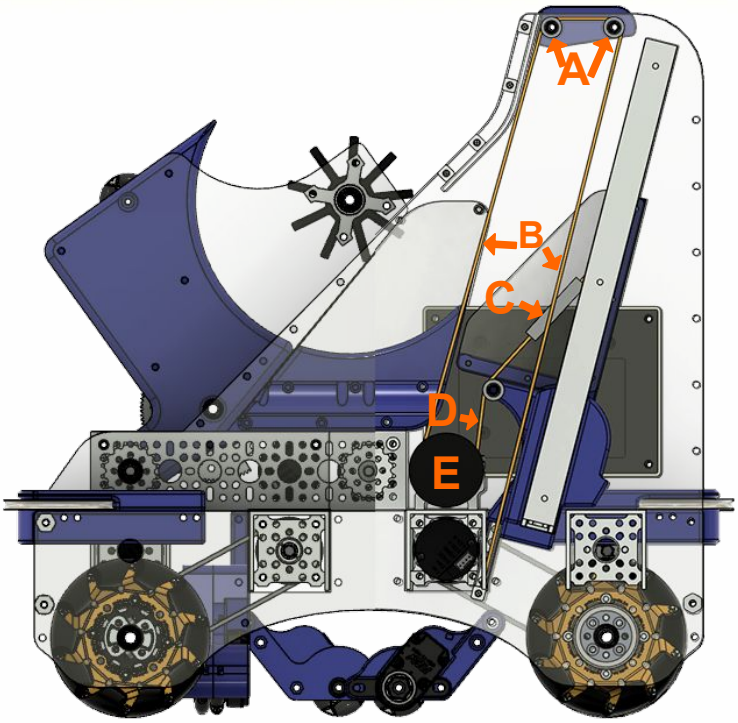
OPERATION TAC 14295

Learn from Mistakes

This is not the first year that we have have had to use line to make a slide extend and retract. However, out of all the stringing assemblies that we have done, this robot is definitely strung the best. **We took what we have learned from previous seasons and applied it to this lifting system.**

Closed System

We REALLY like keeping a closed processing system. This means that we have confined the ENTIRE path of the freight as it travels from our intake to our handoff to our lifter system. Confining the path of the freight prevents freight getting stuck in our robot.

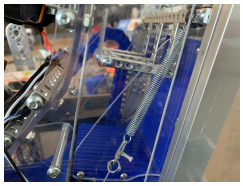


Stringing Legend

- **A** Positioning Pulley Bearings
- **B** Pull-Up Line
- **C** Spring
- **D** Pull-Down Line
- **E** Spool

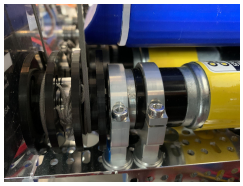
Spring Close Up

Most string stretches over time. To reduce this problem, we use Spectra line instead of Kevlar, as Spectra doesn't stretch. However, as the knots in the string tighten, slack is produced in the lifting system. Over time, it accrues, especially if the pull-up and pull-down lines are not parallel. To surmount this impediment, we installed a spring in the pull-down line. This keeps both strings slack, and keeps our lifter in real time.

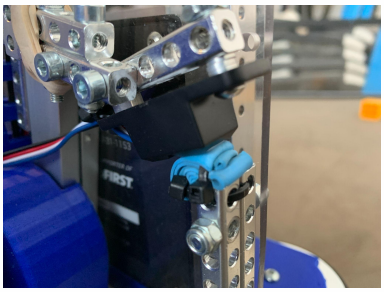


Spool Close Up

Double-stringing the lifter is one of these lessons learned. In the past, we have used surgical tubing or gravity to retract the slide. By installing two spools, (one to pull the lift up and one to pull it down, we are making sure that we are not letting string out of one spool faster than the slide can retract, which can cause the string to jump off the spool. With the double-strung system, the lift position is accurate and operates in real time. We really like reducing risks, and we try to do it as often as possible.



Touch Sensor Calibration

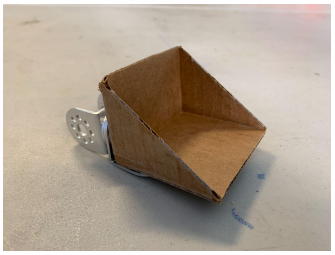


Lifting Logic

We wrote code to calculate the **proportional lift power**, taking into account the distance between the current and target positions. In order to move the lift, we increased the power until the lift starts moving - **this prevents stalling.**

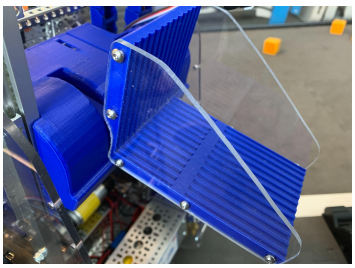
Dumper Prototypes

#1 The dumper design of our robot is simple. It takes the freight from the intake system, lifts it to the correct height on the shipping hub, and places the freight onto the shipping hub. The dumer we first made was very flimsy and the freight would easily fall out.



#2 We really liked this second iteration because it helped control the freight better. It would not let the freight fall out as easily. The problem with this iteration of dumper was that when we rebuilt a smaller robot (Spunky Jr.), it was not compatible.

#3 Our third iteration was our favorite but also our most complex because we figured out that the **more ribs** our dumper had, the less friction it placed on the freight. Because of this, it was very fast at deploying the freight at the correct level of the shipping hub.



Odometry

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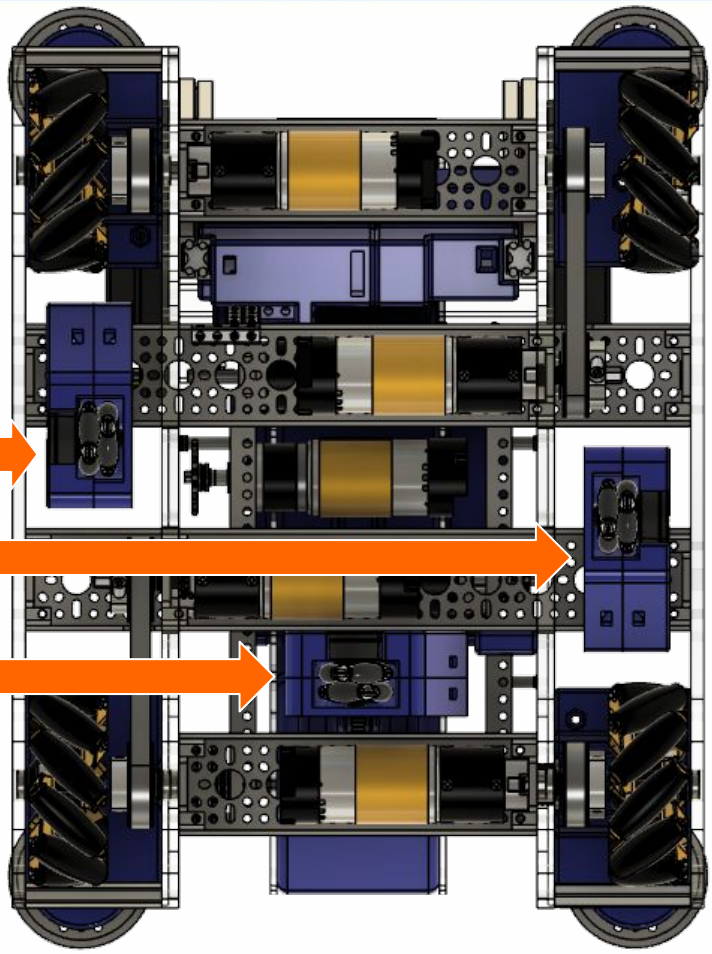
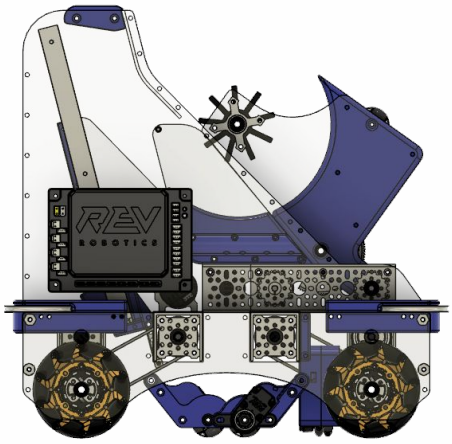
Proudest Accomplishment: It was our goal from the start of the season to use odometry. But there was a problem. We needed the ability to drive over the barricades, but we wanted dead wheels in order to use odometry. We calibrated Road Runner to work for Meet 2 using our drive encoders. This was far more accurate than using normal dead reckoning, and it allowed us to drive in complex patterns.

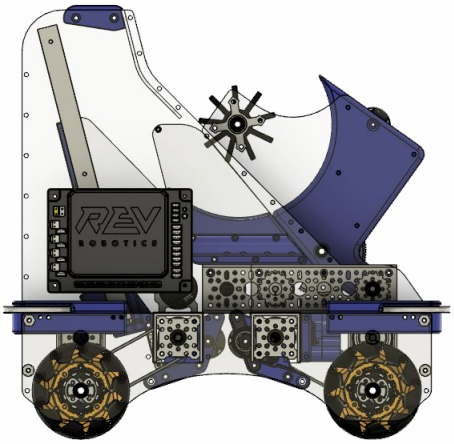
However, we were definitely aware of its problems. If the wheels spun out or the robot ran over the duck or TSE, the rest of our autonomous could not recover. For this reason, **we decided to figure out an innovative way of using dead wheels that we could lift out of the way** at the end of autonomous in order to be able to clear the barricades.



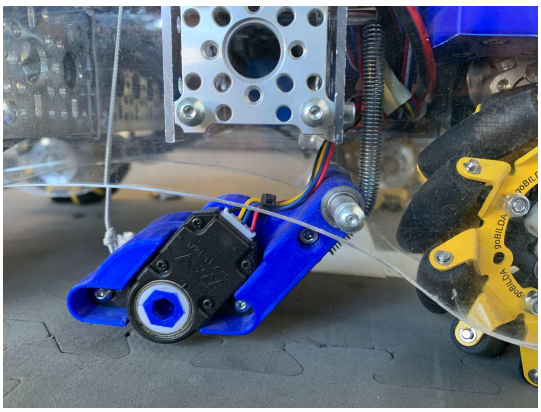
Because our motors are staggered, the left side of our drivetrain is not a mirror of the right side - it is a rotation of it. Because of this, we were unable to have the left and right dead wheels facing the same direction. The good news is we have not had a problem with our dead wheel orientation.



Odometry Pods Down



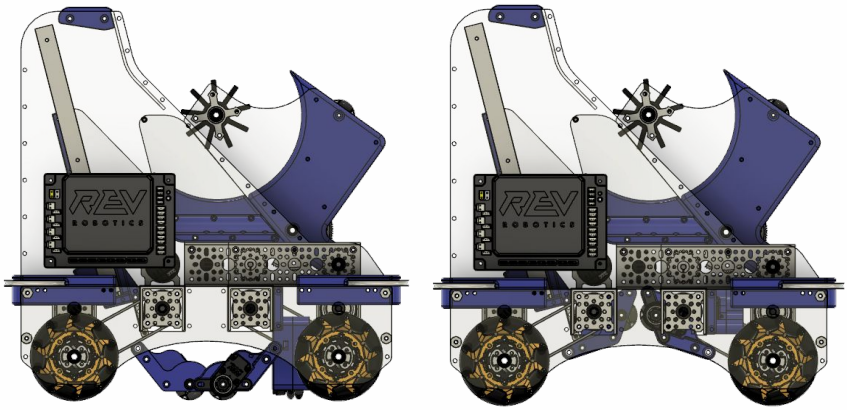
Odometry Pods Up



Since we have channels spanning our drivetrain, we chopped part of the channel above each side dead wheel in order to make it fold out the way far enough. With a simple servo pulling a string, we are able to pull our dead wheels completely out of the way of any field obstacle. **Our base, with our dead wheels retraced, is able to clear the spikes attached to the barricades.**

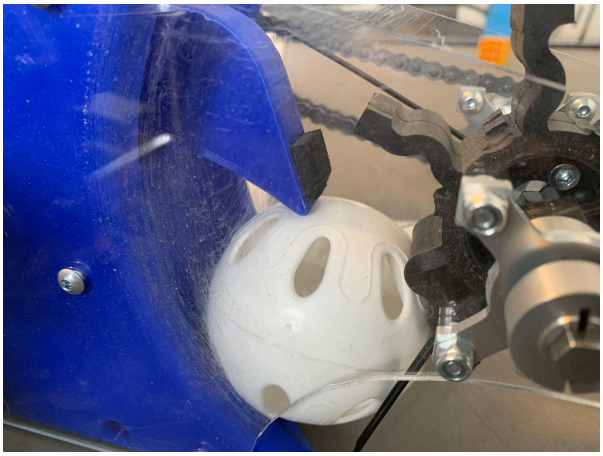
Retractable Dead Wheels (page 13)

During the design process, we had to **overcome obstacles**. For example, we wanted to use odometry pods in autonomous but also be able to clear the barriers in teleop. We solved this problem by using retractable dead wheels. Our odometry pods that fold into our drivetrain are one of our favorite innovations because they drastically improve the consistency and capabilities of our autonomous. With a simple servo pulling a string, we are able to pull our dead wheels completely out of the way of any field obstacle. **Our base, with our dead wheels retraced, is able to clear the spikes attached to the barricades.**



Retractable Intake Finger (page 11)

A challenge we overcame was that our intake was shooting freight out the top. We solved this by having a retractable intake finger that prevents the freight from escaping when the intake is down, but then folds out of the way when the intake lifts. This is a geared finger that blocks freight from coming out the top of the intake when down, but easily folds in the next slope when the intake is up. **The retractable intake finger controls freight.**



Polycarbonate Cutting Method

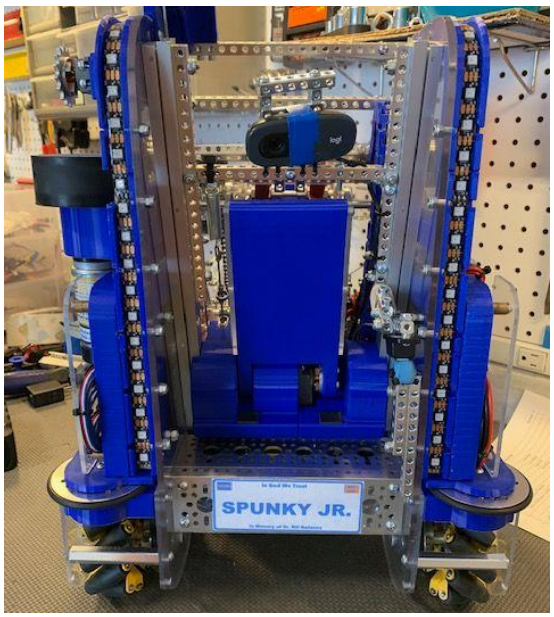
Step #1 - Our team figured out that instead of eye-balling our pieces to cut out, we printed the CAD drawing of the object that we wanted to custom cut. Then, we taped the paper onto whatever we were cutting and traced the lines with our cutting devices so that it would be an accurate cut.

Step #2 - After we cut out our custom pieces, we peeled of the melted plastic that was on the edges of our Polycarbonate. Then we sanded the edges until it was smooth.

Step #3 - Next all we had to do was drill the holes for our parts. If we had more than one of the same things to drill, we taped them together and drilled them both at the same time.

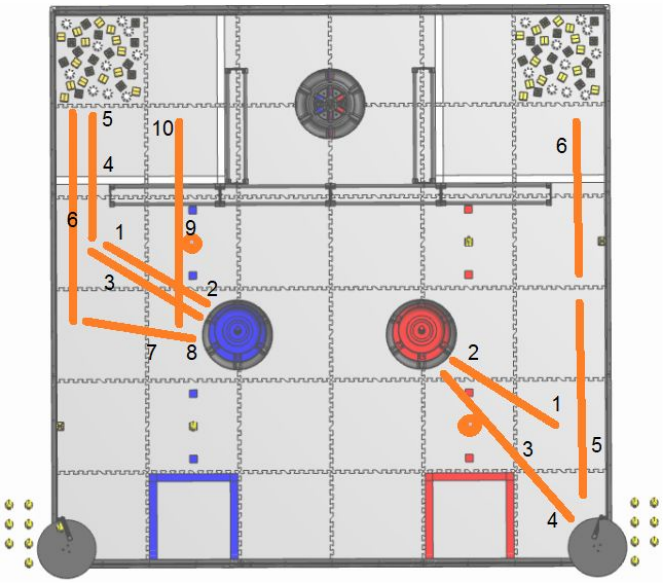
Programed LEDs

We programed the LEDs to tell us if we have a ball or block in our intake. The driver can then decide where to place the freight. We also have **13 sensors on our robot**!



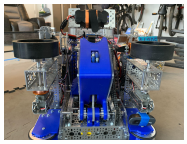
Gamepad A

Gamepad B



Warehouse Path (Our Favorite)

Step 1 – Robot scans the barcode and determines the correct height of the Alliance Shipping Hub.
Step 2 – Robot Places the Pre-loaded Box on the correct level of the Alliance Shipping Hub.
Step 3 – Robot drives forward and strafes into the wall, facing the Warehouse.
Step 4 – Robot lowers its intake bucket and drives forward completely into the Warehouse.
Step 5 – Robot intakes freight.
Step 6 – Robot drives backward out of Warehouse.
Step 7 – Robot turns its back to the Alliance Shipping Hub and drives backward up to the Hub. Then it places its collected freight onto the Hub.
Step 8 – Repeats steps (2) through (6) one more time.
Step 9 – Robot turns to face the warehouse and drives over the Barricade.
Step 10 – Robot lifts the odometry pods and parks completely in Warehouse.



Duck Spinner

We initially thought the duck spinner would be one of the more simpler tasks, but we soon realized spinning nine ducks off the carousel in endgame proved to be difficult. Because of this, we found a prime location for the duck on the carousel disk. We found that the rim of the disk travels faster than the center does when the disk is spun at a constant speed. With Spunky, we worked to optimize the placement of the duck and ramp our motor power to spin it off as fast as possible. On Spunky Jr. however, we sacrificed the speed of the single motor for the flexibility of alignment of two servos. Now we just spin the servos at full speed.

Duck Path

Step 1 – Robot scans the barcode and determines the correct height of the Alliance Shipping Hub.
Step 2 – Robot Places the Pre-loaded Box on the correct level of the Alliance Shipping Hub.
Step 3 – Robot drives forward and strafes into the wall, facing the Carousel, spinning the duck off.
Step 4 – Robot stops spinning the duck Carousel and waits.
Step 5 – When there are just a few seconds left in the autonomous period, robot drives to the Warehouse and prepares to enter (robot waited so long so that his alliance partner could park).
Step 6 – Robot drives completely into the Warehouse.

Programming

OPERATION TAC 14295

Duck Spinner Program

We use an automatic duck spinner program. One push of a button in endgame and all 10 ducks spin automatically off the carousel, one at a time. By this optimization, we save 33% of our endgame time and allow both drivers to be free to run the turrets.

Math PID Algorithms

PID Formula:

$$f(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt}$$

Simplifies To:

$$f(t) = K_p P(t) + K_i I(t) + K_d D(t)$$

We used this formula in our code for the PID Controller.

Automated Parts of Telop

We automated some parts of our TeleOp. For example, when we intake freight, two sensors detect when the intake has a piece of fright in it, allowing the robot to programmatically process the piece of freight without additional driver input.

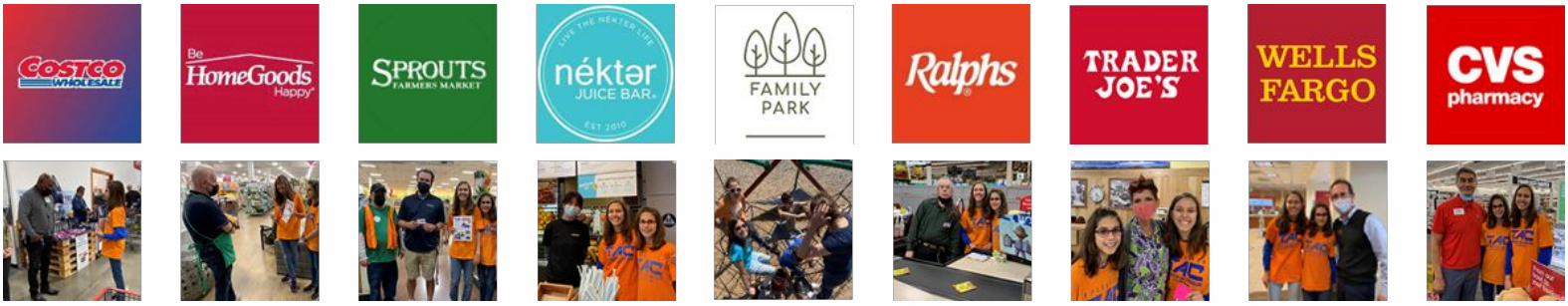
Team Shipping Element

Our team shipping element is designed to be easy to use, failsafe & stackable. It's light and is picked up with magnets that grab the button head screws located at its top.

Our team shipping element arm is made out of polycarbonate. It lifts using two servos (one on each side), and a chain keeps the extension level while the large part of the arm rotates. The part that picks up the team shipping element uses a linkage mechanism to pull a magnet away from the team shipping element, causing the TSE to fall on top of the shipping hub.

Team Shipping Element Arm

We are passionate about being ambassadors for FIRST Programs!



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We had **5** returning and **13** new sponsors for a total of **18**!