STEEL EELS
18317

FIRST TECH CHALLENGE

POWER

PLAY

2022-2023
ENGINEERING PORTFOLIO

18317 Steel Eels

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MEET THE EELS

TEAM PLAN

Introducing the **Steel Eels!** We're diving deep into the world of ***FIRST*** Tech Challenge with two years of experience under our belts, and we're ready to rise to the surface as a more recognizable team this year. With a dedicated and determined group of students, we are prepared to tackle the challenges that come our way and push ourselves to new depths.

Our team comprises hard-working students with various skills that we have used to complete this year's challenge. We have been learning more about how to improve our robot and the skills it takes to manage and work as a team.

SPONSORS

Opus coffee

Pratt & Whitney – Dependable Engines

Department of Defense DoDSTEM – Science · Technology · Engineering · Mathematics

ROSS Dress for Less

PK Yonge

ELITE Auto Center of Gainesville

Slice Engineering

Harbor Freight Tools for Schools

2022-2023 TEAM GOALS

- *Reach out as FIRST* Ambassadors by hosting, supporting, and **attending 30 outreach events** and **contributing 497 volunteer hours** (collectively as a team) this season alone.
- **Support Assistive Technology/#FIRSTwithAT initiatives** in local and national communities by **attending and hosting over 5 AT events.**
- **Achieve proficiency with professional project management tools** to organize our team and connect more with the professional community, which elevated our skills in CAD, programming, and leadership.
- **Fully design a CAD model of our robot**, and utilize advanced techniques such as **custom CNC machining** and **3D printing.**
- **Raise 5,000 dollars** through sponsorships and fundraisers, so our team can provide life-changing benefits at **no charge to its members.**

Our team has exceeded all the stated goals for the 2022-2023 season.

2023-2024 TEAM GOALS

- **Host an additional five outreach events** by expanding our personal connection with communities outside of FTC.
- **Mentor/assist** a minimum of 2 local FLL teams & 1 rookie FTC team
- **Aid with more local and national communities** through our Assistive Technology/#FIRSTwithAT initiative.
- Reach out as FIRST Ambassadors by hosting, supporting, or attending a minimum of **30 outreach events** and contributing **over 500** volunteer hours (collectively as a team) throughout the season.
- **Co-Host** a week-long summer STEM camp **at our host school to get kids interested in STEM & FIRST.**
- Continue expressing our team spirit and personality through **season-themed imagery.**

EEL MENTORS

Our team is **student-led and mentor supported.** We have been fortunate to receive help from college mentors, FIRST Alumni, engineering professors, and industry mentors.

Industry mentors enhance knowledge in many areas of our team, such as robot design, leadership and management, imagery, and intrateam skills. In addition, mentors who specialize in outreach and business teach us the process of building local and statewide connections within both ***FIRST*** and our communities. These skills will prove extremely useful in our future college and career readiness.

Dr. Carl Crane has played an integral role in regularly helping us with our robot's programming & design reviews. He also attends our league meets and provides timely support when needed.

Dr. Carl Crane

Blake Sanders

Former ***FIRST*** Alum of FTC 10497 and Dean's List Winner, Blake, mentored us in components of PIDF, organized our team's GitHub repository, and provided us with other tools and resources to enhance our programming capabilities.

Bill Miller

Mr. Bill is one of our team mentors who helps with field set-up, power tools, team management, and emotional support. In addition, he helps us prepare for meets, packs supplies, and manages meals, transportation, and logistics.

Ben Rodkin is also a ***FIRST*** Alum from FTC 10497. He provides us with programming help by sharing his experience on topics such as state machines, commands-based programming, and automated scoring during TeleOp.

Ben Rodkin

Mika is the President of Swamp Launch, a Rocket Team at UF, and an Alum of FRC Team 3653. Her rocket team designs manufactures, and launches high-powered rockets. In addition, she provides the Eels with technical feedback in OnShape & helps with mechanical questions.

Mika De Gracia

Abi Hendrix

We were paired with a software mentor from the ***FIRST*** Mentor Network, Abi. She has helped us with programming using OpenCV, tuning our PIDF Controller, and teaching us about the algorithms and how to implement a state machine.

Ben Sanders

Mr. Sanders is a Mechanical Engineer and was previously an FTC coach for 10497. He has mentored us in mechanical design by attending our design reviews, where he shared insight on various concepts. He also shares advice for team management and cheers us on at team events.

Jackson, a ***FIRST*** Alum for FRC 4118 Roaring Riptide, helps our team with programming syntax and advice on team management. He has also assisted us in soldering workshops and taught us how to make adaptive technologies, such as switches for people with disabilities.

Jackson Fugate

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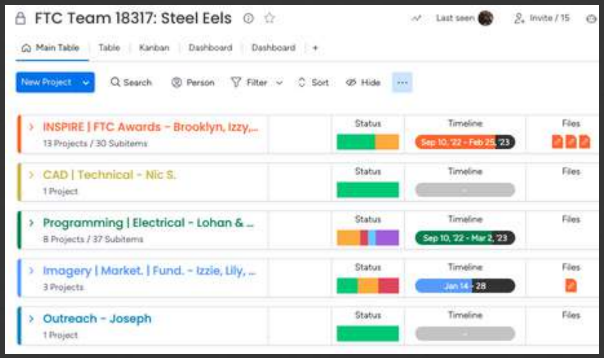
AN EELIE GOOD TEAM

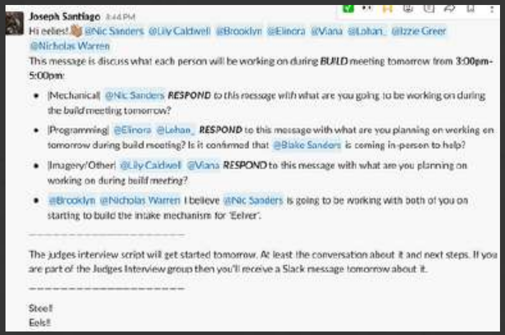
ORGANIZATION

MANAGEMENT

Monday.com is one of our **main ways to keep track of our projects and updates**. It's organized in terms of our sub teams, and within it we have our tasks, status, files, due dates, and timelines.



COMMUNICATION



For **communication** purposes, the Steel Eels use Slack, a messaging app, that lets users communicate within their organization. Here, we share our **team recaps**, which are summaries of each subteam's tasks for the week, and the future goals that we set for ourselves and our team.

ALL-INCLUSIVE

The Steel Eels team **holds regular meetings** using Zoom to review our progress, goals, and plan for future growth. This allows us to efficiently communicate and stay on track toward our objectives.

SUSTAINABILITY

We **recruited new members** by reaching out to our school community through outreach events and robot demos. Because of this, we have **increased our team members by 125% since last season**. To focus on **economic sustainability,** we reached out via email and social media, **obtained five new sponsors**, **organized three different fundraisers**, and submitted the TERRA Grant, funding our new CNC Machine to provide both our FRC Team and future Eelies with tools necessary to hone and develop their skills. **We increased our outreach events by 650%** from 2021 to 2023. Last year we had four outreach events, while this year, we participated in 20. This season we have **reached 1,500**, compared to the previous season, where we reached 121.

INCOME

Our team remains **sustainable** by making sure we have carryover of funds every year.

Income	Info
$979.28	Balance Forward (21-22)
$200.00	Elite Towing
$1,535.00	Student Fundraising/Fundr.
$525.00	Donation
$500.00	Maker Faire Orlando
$220.80	Donation/Dr. Crane
$50.00	brian kramer/ - St. Atty C8
$50.00	Ross
$200.00	Harbor Freight
$3,000.00	TERRA
$7,260.08	INCOME

Expenses Total	Company
$642.82	LVR Ink
$711.80	GoBuilda
$300.00	Ren Jax
$500.00	FIRST
$28.17	VBelts
$500.00	Hotels
$200.00	Scrubs by Desig
$97.45	Amazon
$126.39	Rev Robotics
$2,976.00	Omio
$6,082.63	EXPENSES

FUNDRAISING

TERRA GRANT

Wrote and received a grant from TERRA for **$2,926** which was used to purchase an Omio x8 CNC

MAKER FAIRE ORLANDO

Assisted at the Learn to Solder station at MFO, earning **$500**

Maker Faire Orlando

SHERWOOD FOREST FARMS

Sherwood Forest Farms

Earned $200 from selling holiday decorations

OPUS COFFEE FUNDRAISER

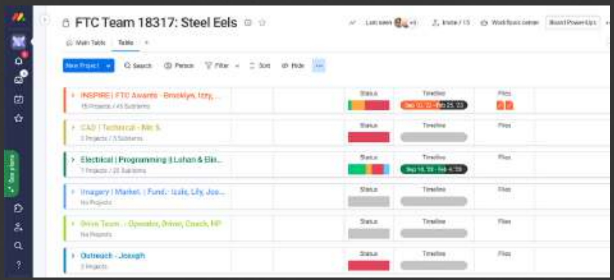
Earned $1000 through a chance donation promoted through social media.

TEAM REVIEWS

TEAM MANAGEMENT REVIEWS

MONDAY.COM REVIEW

Our team had the privilege of engaging with the Academic Partnerships and Management Team of Monday.com. In particular, we discussed the implementation of **due dates, workflows, and KANBAN charts** to enhance our team's productivity and efficiency.



LEADERSHIP & SUSTAINABILITY REVIEW

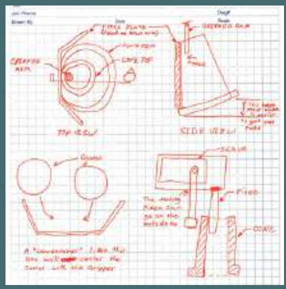
We met with Jeff Steele, Regional Sales Manager of United Electronics Industries (UEI), at the I/ITSEC Conference. Mr. Steele, who is also a mentor for several FTC teams in New Jersey, **provided valuable insight and guidance on a range of subjects pertaining to our team's operations.** These included topics such as team leadership structures, decision-making processes, workflow, and sustainability, with an emphasis on training and development for new team members.

United Electronic Industries

DESIGN REVIEWS

Ray Bolen
Engineer, Mech Systems

MOSES ENGINEERING



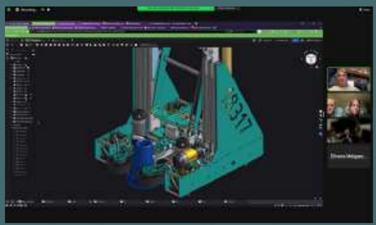
Our team's lead robot designer met with Ray Bolen and Paul Dickhaus of Moses Engineering to **receive feedback on the concept design of our robot's gripper.** They provided valuable insights and recommendations that were considered in our improved design. We appreciate their expertise and time and look forward to future collaborations.

James Young
HWIL Model & Simulation Manager

AXIENT

Met with HWIL Model & Simulation Manager, James Young, to **discuss effective strategies on managing mechanical and software tasks in parallel.** Additionally, we learned about leadership best-practices such as setting SMART goals, effective communication strategies, how to clearly define team member requirements.

Brian Chee
University of Hawaii at Manoa
GSA Office of Info Security



SKY FIBER HIGH SPEED INTERNET

Our lead robot designer, as well as one of our programmers, had the opportunity to meet with Brian Chee of Sky Fiber to seek feedback on the design of our V2 robot. Mr. Chee **provided insights on the CAD model of our robot and real-world examples we should look into for iterative design.**

SCHOOL-BASED OUTREACH

ELEMENTARY MORNING SHOW

Reached our K-5 community of 400 students by showcasing our team and robot on the Elementary Morning Show

ELEMENTARY LUNCH DEMO

Ran a lunch demo and shared more about parts of the ***FIRST*** **FTC** programs with **~ 100 4th-5th Grade Students**

GEMS UF ROBOT DEMONSTRATION

Reached **~30 UF Girls Empowered by Math & Science (GEMS) non-profit organization** by demoing our robot during their club meeting.

MEET & GREET - PK CLUB SHOWCASE

Reached ~100 parents & students and showcased the ***FIRST*** programs at our school, including FLL & FTC at PK Secondary Open House.

HOMECOMING PARADE

Reached ~200 event attendees by participating in PK's Homecoming Parade with our team and robot

WINTER MARKET

Reached ~50 event attendees by participating in PK Student Government's "Winter Market" on campus

FTC ROBOTICS LAB TOUR WITH UF 3D PRINTING CLUB

Hosted a tour of our robotics lab for 5 members of the UF 3D Printing Club to share more about FIRST, Steel Eels outreach, and other STEM efforts.

ASSISTIVE SWITCH BUILD FOR MAKERS MAKING CHANGE

Hosted adaptive switch build and invited Team 4118: Roaring Riptide **~8 switches built in total**

MEETING WITH WECE FROM UF

Hosted the Women In Electrical and Computer Engineering (WECE) student organization from the University of Florida at our build space, building connections through FIRST

PK RETIRED TEACHERS TOUR

Reached 15 retired teachers from PK during a tour. We demoed our robot, showed them our robotics lab, & informed them about the FIRST programs offered within our school.

G.E.M.S. UF STEM ACTIVITY

Ran a **STEM activity with GEMS (Girls in Engineering, Math, and Science),** where they designed and tested paper stomp rockets. We taught them the science behind the rockets and the engineering design process.

BLUE WAVE SECONDARY OPEN HOUSE

Reached ~10 families by holding an open lab tour during our school's second semester open house.

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COMMUNITY

@ALACHUA COUNTY

CO-HOST FLL QUALIFIER

Supported FLL 5798 Frogmen in hosting an FLL Qualifier by volunteering as set-up, judging, and assistants at the event in Alachua, Florida.

BUILDING FLL GAME TABLES

Hosted FLL Table Build - Sourced and **built 6 FLL game tables** for a local practice event. **$489 in material costs was donated** by the High Springs Fire Department

DAFT COW ROBOT DEMONSTRATION

Reached 25 patrons at Daft Cow in San Felasco Tech City and showcased what we do as a FIRST FTC team and how we impact our local community

MENTORING FLL 50798 FROGMEN

Mentored FLL 50798 Frogmen in all aspects of FLL. Our pitch team reviewed their judging presentations over 8 times and gave mentorship on improvements to make.

HOLIDAY TOY ADAPT-A-THON & SWITCH BUILD

Hosted Holiday Toy Adapt-A-Thon/Toy Hack to provide adapted toys for children with disabilities.

GAINESVILLE HACKERSPACE DEMO

Reached ~20 hackers at the Gainesville Hackerspace when we presented our team's different **outreach projects** as well as **demoed our robot, Eelver.**

IEEE UF

Hosted a robotics lab tour with the **Institute of Electrical and Electronics Engineers (IEEE)** from UF. We are planning to work together to create a **mentorship program** so they can help with our future endeavors.

TOY DELIVERY TO SYDNEY LANIER

Assisted with toy delivery event of 8 adapted toys to students at Sydney Lanier School, in Alachua County Public Schools for the holidays

HOLIDAY TOY DELIVERY

Hosted adapted toy pickup and family meet & greet where Harper received a talking dinosaur and a singing Minnie Mouse to Harper, a local child who has cerebral palsy (used with permission).

HOLIDAY TOY DELIVERY

Hosted adapted toy pickup and family meet & greet Delivered an adapted toy - a bubble blower to Ivy, a local child who has cerebral palsy (used with permission).

@STATE OF FLORIDA

SPARK STEM FEST ORLANDO

Showcased FIRST and demoed our robot at SPARK STEM Fest which is an event that ignites curiosity in STEM, where we got kids excited to drive the robot and score points, encouraging them to get involved with FIRST.


COLLEGE OF EDUCATION GIVING DAY

Presented at **University of Florida's** giving day, **showcased our robot & outreach with AT, promoting FIRST** & forming new connections for future team sustainability.

SPACECOM

Attended **SpaceCom** in Orlando where we spoke with many **industry professionals**, building connections and **showcasing our robot**, as well as our **outreach with AT**.


AT TOY DELIVERY

Shipped out 5 adapted toys to a **teacher in Virginia** for her children to be able to play with in the special education classroom.

ASSISTING FTC TEAMS

Supported over 7 teams in person and 8 teams virtually providing feedback and guidance on all aspects of FIRST. Created **Open Source** slide insert design used by over **40 teams globally.**

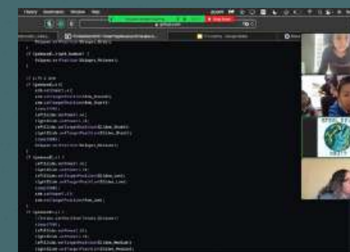
@NATIONAL

#TIDALWAVEOFAT PARTNERSHIP WITH 4118

Assisted partnership with international non-profit Makers Making Change & FRC 4118 - to **teach a student from California how to build an accessible switch & adapt a toy for the holidays.**

ROOKIE TEAM FTC 22471 - TECHATTACK

Assisted Team 22471, techATTACK, from Walnut, California, with coaching tips for meets & java-programming support. Through this meeting, we were able to help them learn about state machines and color sensors.



SLICE HOTENDS PARTNERSHIP

Partnered with SLICE engineering to provide 25% off orders of $99.99 or more to all FIRST teams. Currently 4 teams have purchased these 3d printer upgrades.

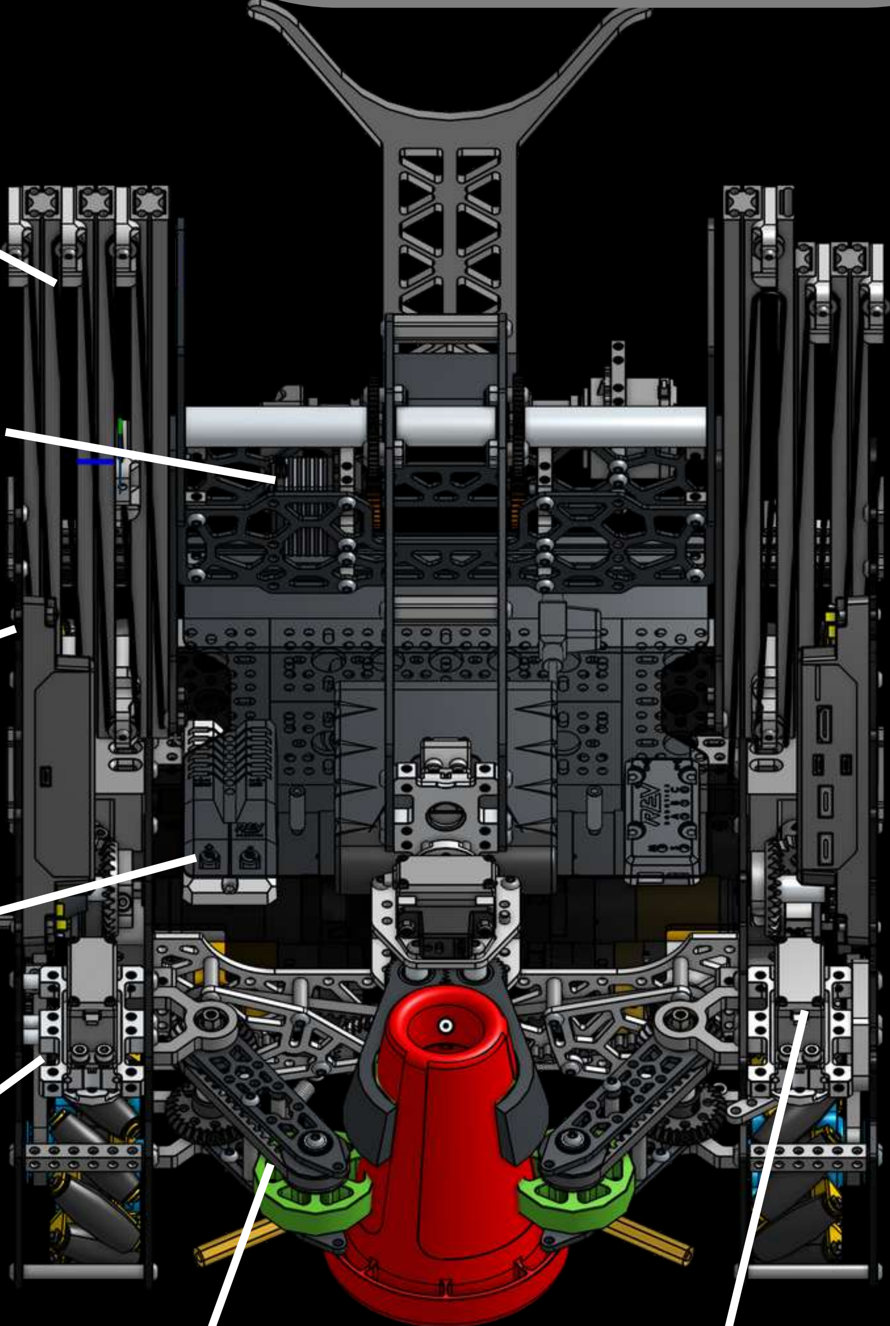
REPRESENTING FIRST AT I/ITSEC

Reached 100+ attendees when we demoed our robot at Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) in Orlando, Florida

FTC 18253 - BEACH BOTS

Mentored a California FTC team virtually in areas of mechanical design, CAD best practices, and judging submissions. Communication was maintained in accordance with FIRST guidelines.

ROBOT OVERVIEW + GAME STRATEGY



AUTONOMOUS STRATEGY

- Always park in correct zone using vision processing (20)
- Score pre-loaded cone onto high junction (5)
- Cycle 4/5 cones from starting stack onto nearest mid junction (16-20)

TELE-OP STRATEGY

- Have the ability to score on every height level junction
- Never knock a cone over when grabbing or placing
- Minimize driver error in grabbing cones with intake mechanism

ENDGAME STRATEGY

- Prioritize endgame possession over raw cycles on high goals
- Defensive circuit strategy which focuses on stopping opponents circuits before finishing ours

STRATEGY VALIDATION

- Our game strategy undergoes constant improvements using **statistics** such as points scored and on which junctions that are **gathered from every match** we play during meets

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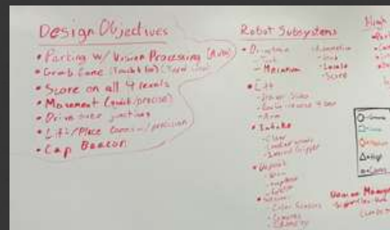
STEPPING INTO THE OCEAN OF DESIGN

MECHANICAL

BRAINSTORMING

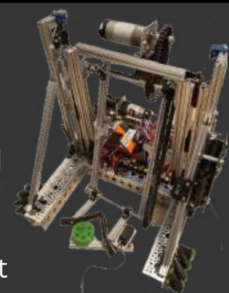
To determine our robot design, we:

- Created a scoring matrix with possible point values for specific strategies which informs our final game strategy
- Robot designs are then split into individual subsystems from which we determine our leading candidates for each mechanism

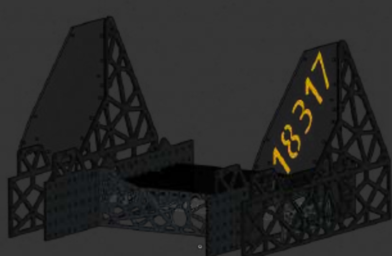


TESTING AND ANALYSIS

- Leading mechanism concepts are prototyped in real life to validate ideas
- Completed prototypes are then added to a drivetrain and are tested in real match environments throughout our first three league meets as our V1 robot



CALCULATE AND CAD



- Using data collected from prototypes in matchplay, all final mechanisms are designed in CAD, allowing for optimized shape, weight, and robustness.
- Torque calcs drive motor/servo decisions & material thickness
- Saving time & resources, the majority of design iterations done in CAD

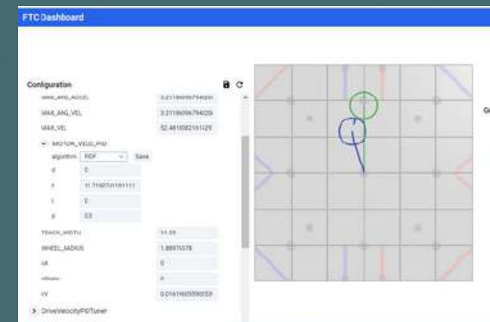
DESIGN FOR ADJUSTABILITY

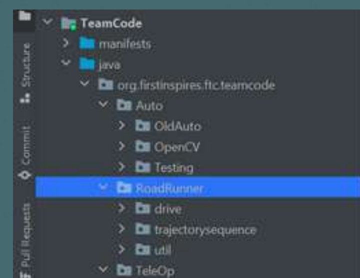
- This year we put a significant emphasis on creating our parts with adaptability in mind. We use a standardized 16x16mm grid m4 hole pattern to be able to mount with modifications later in the season.

PROGRAMMING

BUILD ON THE WHEEL

- Our team utilizes open source libraries like Road Runner and EasyOpenCV as a framework from which we can implement our own solutions into our autonomous and TeleOp code



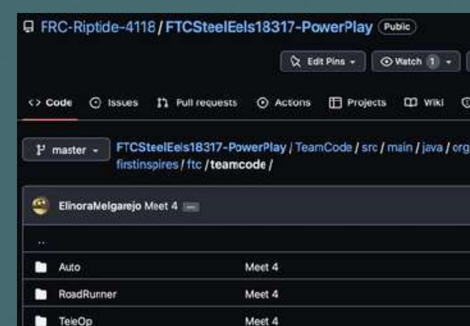


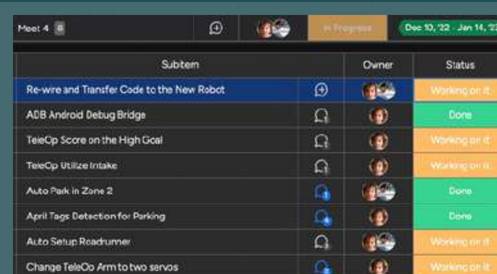
WORK DISTRIBUTION

- Separated the code in Android Studio by our different TeleOp and Autonomous programs for task management.

GITHUB

- As new changes are made, we upload to GitHub for documentation purposes, code reviews, and increased collaboration
- Version control and branching achieved through online repositories





MONDAY.COM

- Monday task distribution for programming is divided amongst two people, with specific deadlines and updates to improve workflow efficiency.

VERSION HISTORY & PROCESS

V1 | Meet 1-4 - AVG: 61.775 pts. High: 174 pts.

Strengths:

- Parking in auto with OpenCV
- Optimized scoring in TeleOp to be automated, as well as fast

Weaknesses:

- Time Management (programming was rushed)
- Our slides got stuck often
- Mechanical Issues with our drivetrain
- Inconsistent Scoring in Auto

V2 | Leagues - AVG: 141.7 pts. High: 229 pts.

Strengths:

- Scored a preloaded cone onto the high junction in auto, as well as parking in the randomized zone.
- We were fast in TeleOp, able to grab as many cones as possible.

Weaknesses:

- Slides got stuck in TeleOp because of string issues.
- Our Drivetrain was having mechanical issues.
- The servos for our arm were malfunctioning.

V2 | States - AVG: 191.28 pts. High: 257 pts.

Strengths:

- Our Slides no longer got stuck during TeleOp
- We were able to score from the stacked cones in autonomous
- Our active intake made it easier to grab cones

Weaknesses:

- Our Scoring was inconsistent in autonomous
- We ran out of charged batteries, due to the servos draining the power

V3 | Worlds - AVG Practice: ~200 pts.

Strengths:

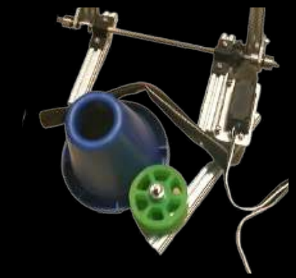
- With our new arm design, our robot can score faster in TeleOp.
- Our autonomous is now more accurate due to the addition of dead wheels on the robot.

Weaknesses:

- Our battery uncharges rapidly, needing to be swapped every match.

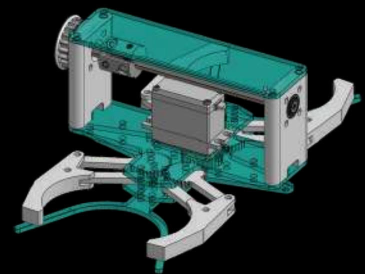
MAJOR ITERATIONS

SINGLE ARM GRIPPER



Couldn't grab cones off the wall effectively

4BAR GRIPPER



4bar took too long to close and pushed cones forward

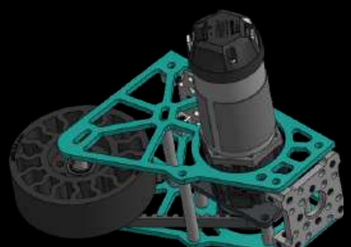
TOP DOWN GRIPPER

Linkage did not fit within constraints

DIRECT DRIVE INTAKE

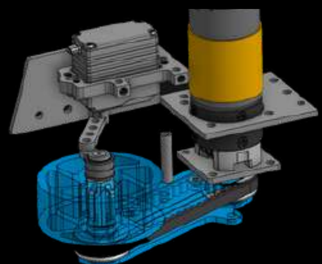
Not robust enough and too bulky

SOLID MOUNTED INTAKE



Blocked cone from transferring to scoring

V1 SPRUNG INTAKE

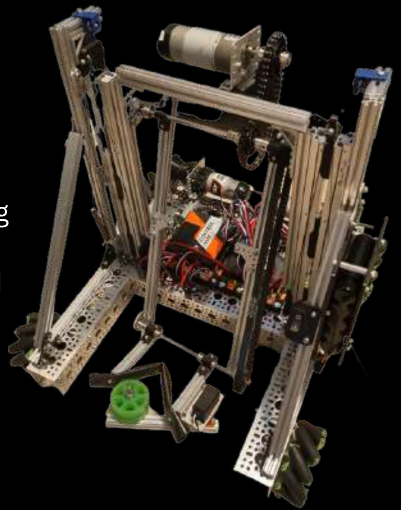


Required 1 motor per module

V1 ROBOT

Lessons Learned

- 18x18in drive base makes navigating the field challenging
- Over a match, 13+ seconds are wasted lining up to pickup cones
- 2x SAR 330 linear slides can't reach the high junction



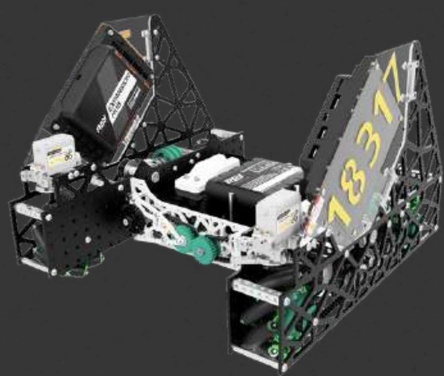
Concepts Validated

- Passthrough scoring mechanism benefits cycle time
- 20:1 drivetrain gear ratio optimized speed/acceleration
- Mecanum drive is the most best wheel option
- Slide and arm speed is a major time loss if unoptimized

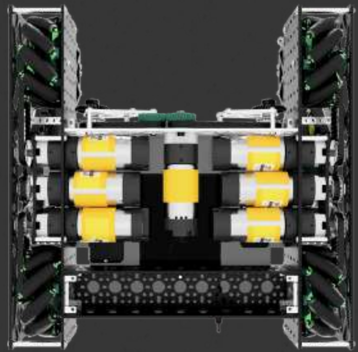
DRIVE TRAIN & CONTROL

MECHANICAL

- **Problem:** COTS drivetrains are near to 18in which makes traversing the field challenging on the driver
- **Solution:** 13x13in custom 4 motor mecanum drivetrain
- **Key Features:** 3d printed pulley and core attach to mecanum wheels to allow for use of compact and robust dead-axle design.
  - Integrated electronics allow for control over wire management.
  - Front structure serves as mounting for spinning wheel intake



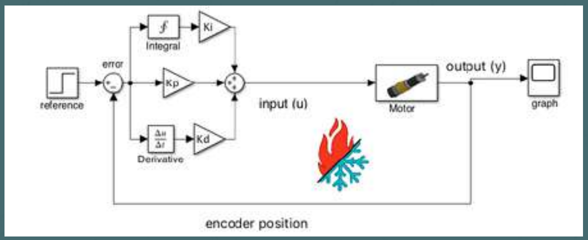
- **Problems:** Minimizing drivetrain dimensions makes packaging challenging
- **Solution:** Unique motor mounting configuration for drive and lift motors maximises space efficiency
- **Key Features:** Extremely compact motor packaging achieved through "sinking" all drive and lift motors into drivepod.
  - All motors centralized and lowered on the robot to achieve an excellent center of gravity to avoid tipping.



PROGRAMMING

UTILIZING PID-F CONTROL

- **Problem:** Having issues executing precise, smooth control of the robot's velocity and acceleration- causing oscillation, which affects the robot's functionality.
- **Solution:** To maximize the effectiveness & speed of each operation, we utilize PID-F to accurately follow paths by continuously adjusting the control system's output based on feedback from the robot's sensors/encoders.



- **P (Proportional):** robot attempts to fix an error by making a correction proportional to the error's size.
- **I (Integral):** robot attempts to fix any long-term errors by considering the total amount of error over time.
- **D (Derivative):** robot attempts to prevent overshooting and oscillation by considering how quickly the error changes.
- **F (Feedforward):** robot attempts to predict what will happen and adjust before an error occurs.

DEAD-WHEEL LOCALIZATION

- **Problem:** It's difficult to control the robot's movement and accuracy autonomously- resulting in errors and inconsistencies. This makes it difficult to program our specific paths.
- **Solution:** Collecting the x and y coordinates of the robot's route can be determined by using a coordinate system. The x and y coordinates of the path are defined by measuring the distance from the origin point to the robot's current position, using two extra dead wheels with just encoders attached to them, helping us see the exact location of our robot.

ULTIMATE DRIVER CONTROL

- **Problem:** The driver needs help consistently scoring cones in TeleOp due to unexpected external factors on the field, like other robots or game pieces.
- **Solution:** We implemented a program called "Slow Mode," which slows down the robot's movement while in TeleOp. This allows for more precise movements, increasing our scoring accuracy at competitions.

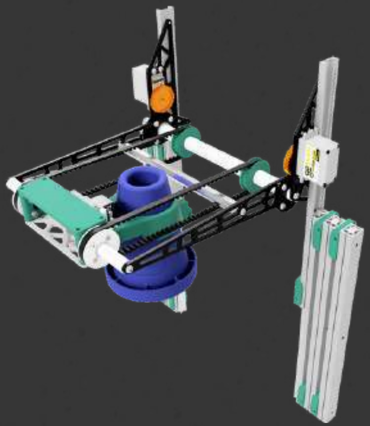
LINEAR SLIDE & ODOMETRY

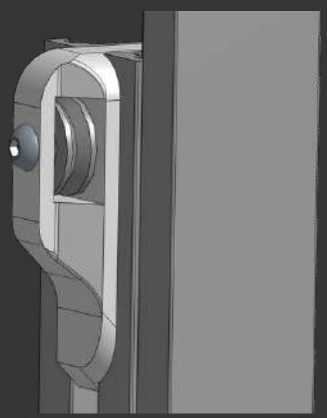
ODOMETRY

- **Problem:** Precise movement in autonomous required to reliably score a 1+5 mid goal cycle
- **Solution:** 2 custom 3d printed dead-wheel modules sprung towards ground tracks robots position
- **Key Features:** Modules mounted to standoff riding between c-channel
- Extension springs used to keep constant contact between ground and wheels
- Rev Throughbore encoder intergreated into module to achieve a 40mm width

SLIDES

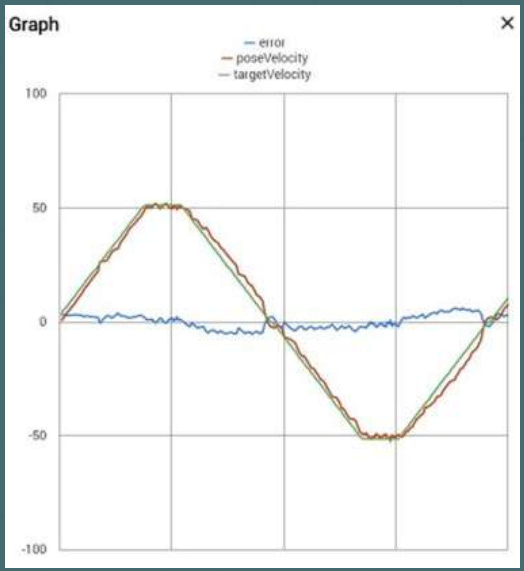
- **Problem:** Our game strategy necessitates fast cycle times on all junction height levels.
- **Solution:** 3 stack of SAR330 linear slides provides over 40in of vertical extension.
- **Key Features:** Custom 3d printed OpInserts and rev v-groove bearings used for smooth continuous rigging of the slide system
    - Inline string pulley paired with springs on tie-off points for string keeps the string from hopping off bearings.





DRIVERS + MECHANISMS

- **Problem:** Having 2 drivers controlling each individual mechanism made scoring slow and inefficient
- **Solution:** Automating the Slides & Arm made scoring a lot faster by using RUN_TO_POSITION with encoders, enhancing our driving and cycle times.
- **Key Feature:** A PID Controller smooths out acceleration for the slides, which decreases torque applied to the string. It also combats gravity when the slides drop, preventing the string from losing slack.



STATE MACHINE + COMMANDS-BASED PROGRAMMING

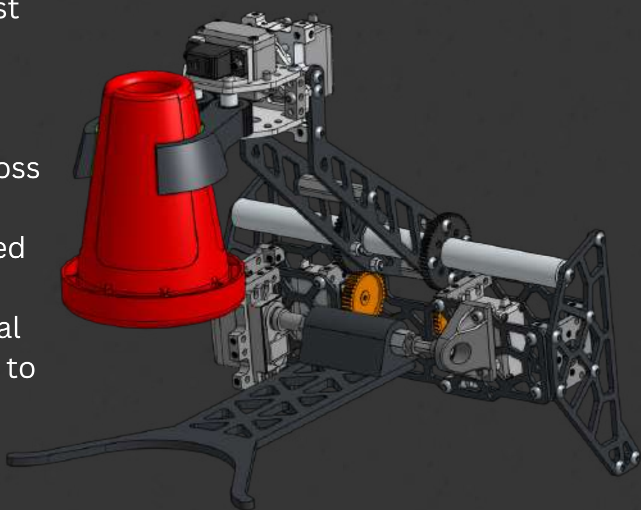
- **Problem:** Having a linear program makes running two mechanisms at once tricky, making the robot score slower during TeleOp.
- **Solutions:** Made a separate subsystem for each mechanism and command, or action, to use throughout all of our code instead of having too much in one file, making our programs more organized and easier to navigate.
- **Key Feature:** Using a finite state machine and commands-based programming, the driver can simultaneously manipulate four mechanisms with one button. With three states in total, the robot can score more efficiently so that we can score as many cones as possible during TeleOp.

ARM & GRIPPER

ARM

- **Problem:** Cone needs to be transfered from an intaking position to a scoring position quickly and reliably
- **Solution:** Dual servo powered lightweight arm mounts to slide system and holds gripper

- **Key Features:** Robust support structure mounts two servos geared to arm
- Arm dead-axled across slides for stability
- Arm weight optimized with removal of unnecessary material
- Arm length reduced to decrease necessary torque to rotate

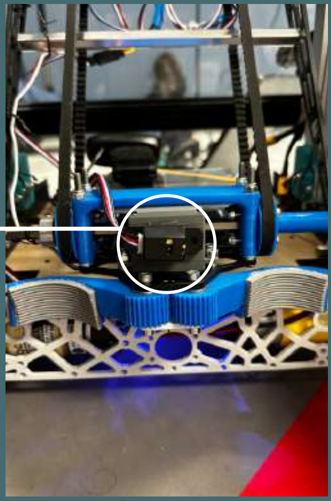


- **Problem:** The 4-bar gripping design is noticeably slower than other solutions, pushing the cone forwards.
- **Solution:** Simplified gripper mechanism uses 3D-printed gears.

- **Key Features:** Design optimized for space efficiency and reliability.
  - Gripping arms use gears which allows for only one servo, simplifying the mechanism and saving weight.
  - Distance sensor used to automate gripping.
  - Compact dead axle design to maximize arm length.

COLLECTION ENHANCEMENT

- **Problem:** Having no automated pickup takes longer to execute & needs to be consistent, resulting in reduced speed/performance. It requires more input from an operator, making it time-consuming & more prone to human error.
- **Solution:** A distance sensor attached to the claw mechanism detects when the intake collects a cone, which helps direct the claw to open when not holding a cone & close when it detects the cone nearby. If the sensor confirms picking up a cone, intake is set to stop completely, preventing any manipulation of additional cones. The arm mechanism is then raised to score using the loaded cone.



COMPUTER VISION

- **Problem:** While using a color sensor works, we did some research and found that using OpenCV makes for a more precise reading, with the ability to detect, process, and convert the image, even if it's not precisely centered with respect to our robot's dimensions.
- **Solution:** We use an April Tag Open CV pipeline, which uses a grayscale and locates and separates the binary picture components. The program then calculates the corners of the April Tag to find its location and orientation. Then, based on the randomized image, the robot parks in its corresponding zone.

MECHANICAL

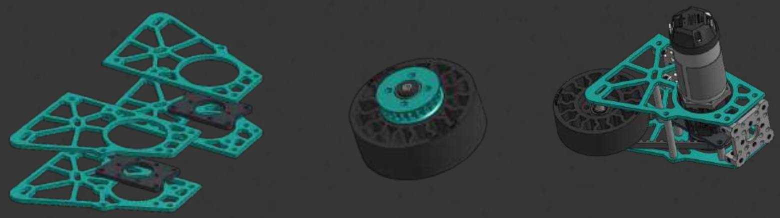
18317 STEEL EELS

INTAKE

PROGRAMMING

WHEEL INTAKE V1 ITERATION

- **Problem:** The time to lineup on cones while collecting was a limiting factor to cycle times.
- **Solution:** A spinning wheel intake system reliably centers the cone into the gripping mechanism
- **Key Features**: Spinning-compliant wheels compress the cone and center it into the robot's gripper, improving cycle times.
  - Robust dead axle design built for contact with other robots.



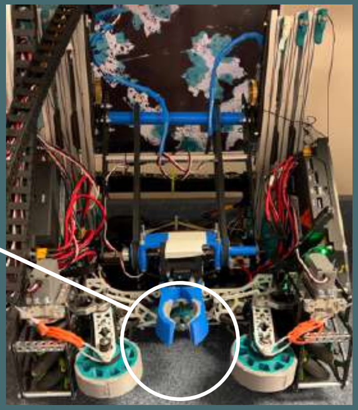
SPRUNG SPINNING WHEEL INTAKE

- **Problem:** Intake wheels stopped arm transferring cone to score.
- **Solution:** Switched intake module to be on a free pivot that was actively sprung inwards and pulled outwards to clear arm transferring to scoring position.

- **Key Features**: Sprung modules allow us to maintain a small drivetrain width while still being able to intake cones and transition to a scoring position.
  - Adding surgical tubing spinners increased the effectiveness of our centering and the total reach of the pickup.
  - Servos mounted in drive pods allow the intake to be retracted and stay out of the path of the cone scoring.

ACTIVE INTAKE

- **Problem:** Using the gripper takes longer to score because of how precise the driver needs to be when grabbing and locating the cones.
- **Solution**: By intaking the cone, it gets it in position for our gripper to quickly grab it, making scoring more effortless and more efficient.
- **Key Feature:** Servos pull the intake wheels out once a cone is detected with the color sensor, enhancing our drive controls.



INTAKE CONTROL

- The motor speeds are manipulated by utilizing the left and right triggers.
- Upon successful intake of a cone, the gripper mechanism is triggered to grasp the cone, thus preparing it for scoring automatically.
- The deployment of the intake wheels is accomplished through the activation of servo motors triggered upon detecting a cone.

HARDAWARE (HW)

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PROBLEM SOLVING

SOFTWARE (SW)

HW Problems:
- Arm motor mounted weakly causing chain to slip
- String Pulley holders bent causing string to fall off

HW Solutions:
- Created support box for arm motor
- Re-designed string pulley holders to be stronger

SW Problems:
- Doesn't always park in the correct zone
- Slides were slow in TeleOp, often stalling

SW Solutions:
- Utilized a color sensor for parking
- Increased power for the slides

HW Problems:
- Drive motor gears began chipping
- Slide string came off v-groove bearings stopping slides from extending

HW Solutions:
- Rebuilt drive motors with replacements
- Added springs to tension slide strings
- Reprinted slide inserts with tighter tolerances

SW Problems:
- Difficulty parking in correct zone
- Slides could be a little faster

SW Solutions:
- OpenCV April Tags pipeline for parking
- Increased the speed for the slides by fine-tuning the PID values

HW Problems:
- String continuously fell off v-groove bearings causing slides to bind
- Cones were hard to grab with just a claw

HW Solutions:
- Printed slide pulley holders that guide the string on the v-groove bearings
- Added intake module

SW Problems:
- Inconsistent Scoring in Autonomous
- TeleOp State Machine, transitions between states are too slow

SW Solutions:
- Tuned motor PID values for scoring stacked cones in autonomous
- Arm moves faster in TeleOp
- Added automated gripping and intake movement with a distance sensor

MEET 1 | MEET 2 | MEET 3 | MEET 4 | LEAGUE | STATES

SW Problems:
- Having 2 drivers was inefficient
- Difficulty parking in the correct zone
- Lack of documentation

SW Solutions:
- Consolidated drive controls to 1 controller
- Parking in zone 2
- Utilized GitHub for documentation

HW Problems:
- Gripper was unable to grab cones off wall
- Motor overheats while holding arm to position

HW Solutions:
- Changed drive path to grab cones away from wall
- Increased gear ratio on arm

SW Problems:
- Inconsistent Autonomous with Parking inaccuracies
- Slide speeds only running at 70% full speed

SW Solutions:
- Tuned Motor PIDF values for accuracy
- Added a PIDF Controller for the Slides to speed up

HW Problems:
- Only functioning component of v2 robot was drivetrain
- Wires were not managed and could be damaged by other robots

HW Solutions:
- Modified game strategy to push cones into ground junctions
- Added cable chain

HW Problems:
- The virtual 4-bar can get caught onto the junctions, and is also inefficient because it could get caught onto the robot itself

HW Solutions:
- Added dead wheels to the bottom of the robot for our auto.
- Replace the arm with one that simply flips, and add a wrist servo to the gripper to flip the cones upright
- Add a mechanical alignment to the robot to be able to line up with the junctions

SW Problems:
- Inconsistent Scoring on Junctions in Autonomous
- The Arm can't move unless there's enough clearance with the slides

SW Solutions:
- Use dead wheels to track precise movement in auto
- Add the new mechanisms into our TeleOp