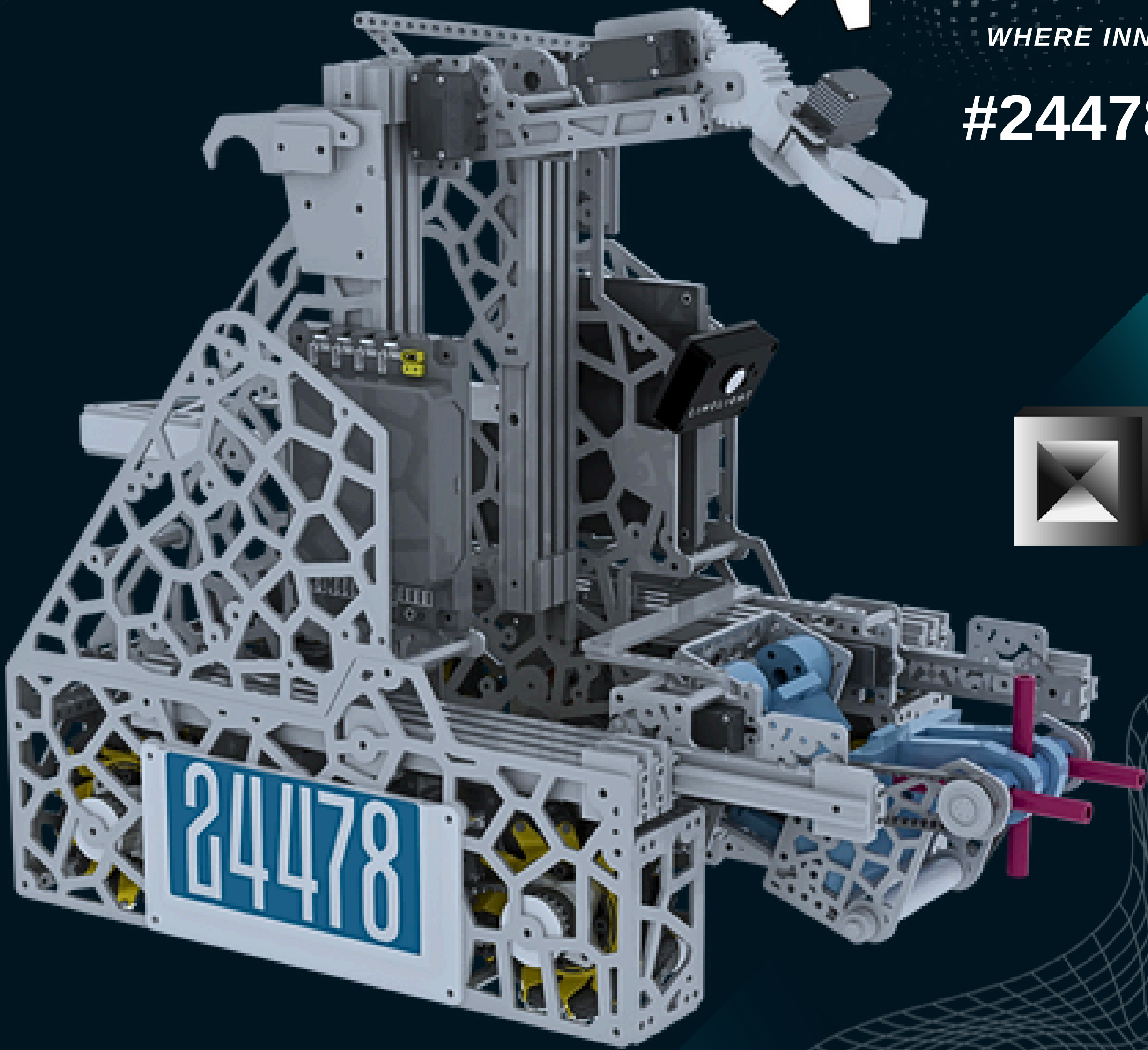
CRI PORTFOLIO

ENGINEERDS

WHERE INNOVATION MEETS COMPETITION

#24478



@cnrgengineerds

@engineerds_ro190

@engineerds24478

@engineerds

BRD | FIRST TECH CHALLENGE ROMANIA | NAȚIE PRIN EDUCAȚIE | INTO THE DEEP

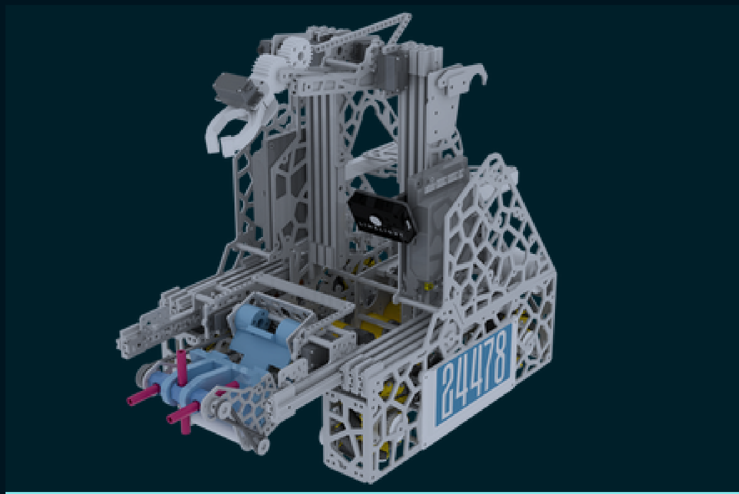
"RADU GRECEANU" NATIONAL COLLEGE
SLATINA, OLT, ROMANIA

TEAM OVERVIEW

ENGINEERDS

We are team #24478, EngiNeerds.

- SELF-FOUNDED FTC TEAM
- ESTABLISHED IN 2023
- NATIONAL COLLEGE “RADU GRECEANU”
- SLATINA, OLT COUNTY, ROMANIA
- 17 MEMBERS AND 7 VOLUNTEERS
- MENTORED BY TWO INFORMATICS TEACHERS
- DIVIDED INTO TWO MAIN DEPARTMENTS



PRESENTING **LUX** OUR SMARTEST, FASTEST, AND MOST RELIABLE ROBOT EVER.

Non-technical
- PR & Marketing
- Technical Writing
- Finance & Sponsorship

Technical
- Mechanical
- Programming
- 3D Design

TABLE OF CONTENTS

- BUSSINES PLAN
- SUSTAINABILITY
- OUR JOURNEY IN SEASON 9
- OUTREACH
- DESIGN PHILOSOPHY + ROBOT VERSIONS
- DRIVETRAIN + CABLE MANAGEMENT
- EXTENSION SYSTEMS + ASCENT SYSTEM
- INTAKE & OUTTAKE – ITERATION PROCESS
- SOFTWARE & SENSING
- DRIVETRAIN CONTROL
- CAMERA VISION
- CODE STRUCTURE + TELEOP AUTOMATIONS

BUSSINESS PLAN

ENGINEERDS

TEAM GOALS

PROMOTING STEAM VALUES

- Visiting at least 2 schools within our community
  - We visited 3 schools out of 6.
- Organizing 10 events and demonstration workshops this season
  - So far, we have organized 14 events.
- Reaching a total of 60,000
  - We have reached a total of approx. 81,000.

UNITY & ORGANIZATION

- Maintaining assertive communication and team spirit, regardless of the situation.
  - We successfully overcame all challenges encountered throughout the season through unity, even in the most tense moments, learning from mistakes to be better and better.
- Clear division of tasks within the team to optimize work and each member’s responsibilities.
  - Through our task management strategy, we created a system where every member or volunteer can get involved and gain experience.
- Efficient time and task management to complete at least 90% of tasks on time.
  - We completed 95% of tasks on time, without major delays.

RESOURCE DEVELOPMENT

- Obtaining a sum of 50,000 $
  Managed to obtain 54,310 $
- Recruiting at least 5 volunteers and developing new team members
  We expanded the team by 9 volunteers, 2 of whom have become dedicated members so far.
- Building valuable partnerships with schools, organizations, and companies
  We developed various ways to maintain the connections we create.

FINANCES

Being a student-led team, all of our funds come from our generous sponsors.

SPONSORSHIP STRATEGY

1. Call/Email potential Sponsor.
2. Meet in person, discuss FIRST, show our work.
3. Follow up with sponsor to share season results, what we learned, and to thank them.
4. Retain sponsor for next year and seek greater engagement

Their support goes far beyond financial contributions - our sponsors also help us by:

- providing custom-manufactured parts for our robot (e.g. Contur Tech)
- delivering full meals directly to our laboratory (e.g. Popas Sport)
- supplying equipment and materials (e.g. Prysmian)

SWOT ANALYSIS

S

- Sufficient Financial Resources
- Strong connections with other FTC teams worldwide
- Passion and ambition to evolve

W

- Not enough people in some departments
- Limited space in the workshop
- Less experience than other teams

O

- Representing the team and the country at the highest levels
- Participation in major national and international events
- Promoting STEAM & FIRST

T

- Unexpected technical issues
- Stress and fatigue
- Limited availability of some members

Season Cost Breakdown

Accommodation	~2.710	$
Transportation	~2.710	$
Robot parts	~27.150	$
CRI	~21.740	$

TOTAL 54.310 $

Remaining: 0$

CIUBOTARU N. VASILE

MAXIMGREEN SAT S.R.L.

COSULTING S.R.L.

VASILE C I S.R.L.

S.C. BEBE TRANS ROM S.R.L.

ANIL CONSTRUCT S.R.L.

MAXIMGREEN SAT SRL

NEW ALTERNATIVE AFFAIRS - TOURISM

SPONSOR RELATIONS

In order to create lasting partnerships that go beyond a single season, we make sure to stay connected and show our appreciation through consistent and thoughtful actions, such as:

- organizing visits to their headquarters
- sending thank-you letters and holiday greetings
- keeping in touch through regular email and social media updates
- hosting special appreciation events to recognize their support

SPONSOR APPRECIATION EVENT

On June 19th, we hosted a special event to thank our sponsors and highlight the real impact their support has on education and youth innovation. The gathering began with open discussions in the school's amphitheater, followed by speeches about our teams' journeys and vision for the future.

We then showcased our robot in action and guided guests through our lab. It was a moment of connection, reflection, and appreciation for the partnerships that make our growth possible.

> The true joy is ours, having the opportunity to support such exceptional young children who prove that passion, hard work, and perseverance can take you far.
>
> - ALRO, one of our main sponsors for our participation at CRI

SUSTAINABILITY

ENGINEERDS

TEAM MANAGEMENT

HOW WE BECOME BETTER DAY BY DAY

HOW WE CLASSIFY & ORGANIZE OUR TEAM'S WORK

We classify and organize our team's work based on:

- Individual and collective tasks – distributed according to each member's skills and responsibilities;
- Time management – we use planning apps to set deadlines, organize events and files, and also to track progress;
- Risk identification – we anticipate blocks or errors and establish preventive solutions;
- Event coordination – we prepare in advance for competitions and outreach activities.

WEEKLY BRAINSTORMING

Every Monday, we hold a team meeting with our mentors in which we:

MON

- Propose solutions and new ideas
- Review the past week's activity
- Assign tasks
- Set priorities for the upcoming week
- Identify emerging issues and risks in ongoing projects

CONNECTING WITH EXPERTS

Even though we are mostly self-taught, we encounter moments when we need guidance. Thus, throughout the season, we managed to keep a great connection with experts in a variety of departments of our team, who are either from companies that sponsor us, or are actually our parents.

- vimetco extrusion & prysmian experts - advice on level 3 ascent
- College Student (former student of Mr. Dumbrăvescu)

- Designing advice: LOGO, color palette, and overall image of the team

PARENTS = KEY ROLE IN OUR DEVELOPMENT

- PIRELLI expert

- Approved gearbox system
- Advice: battery draw issues & best material for slide strings

- Visual graphics expert

- Advice: promotional resources, professional photos/videos, and growing our social media accounts

TECHNOLOGY – KEY TO GREAT MANAGEMENT

To manage our work efficiently, we use a set of tools that help us save time and be better prepared:

- OneDrive – for file management:
- Google Calendar – for planning and tracking events

- Technical: CAD designs and a "Tool Tracking Notebook" that helps ensure we don't forget any tools or components before competitions

- Non-technical: photos and videos from events, logos, graphic materials, and useful tables

HOW WE GROW OUR TEAM

RECRUITING PROCESS

Volunteering = the first stage of entering a team, in which you integrate & gain experience to eventually become a reliable member of the team. Another way to become a volunteer is if you can't dedicate enough time to actively support it.

Volunteers have the opportunity to work directly with the team under constant guidance and also be involved in practical activities and training sessions. At the end of the volunteering period, those who have demonstrated seriousness, curiosity, and a desire to learn can become official members of the team.

OUR JOURNEY IN SEASON #9 "INTO THE DEEP"

ENGINEERDS

MEETS

CHALLENGES AND HOW WE OVERCAME THEM

1. Major electrical failures (SPM, power button, servos) impacted the entire system during competition => Despite the difficulties, we managed to fix everything in time, which tested and strengthened our ability to react quickly and work under pressure.
2. Autonomous sequence tuning => we continuously worked to achieve a consistent autonomous sequence capable of placing 5 specimens — an effort that directly translated into our high scores.

PERFORMANCE OVERVIEW

- 5 meets attended
- 21 matches won out of 30
- Frequently scored over 270 points
- Ranked first in two competitions
- Remained consistently in the top 10 of Western League => reached 7th place overall.
- Best performances: 324-point match alongside Rasky #19109 & 344-point match with Cybermoon #19256

WEST LEAGUE TOURNAMENT (REGIONALS)

CHALLENGES AND HOW WE OVERCAME THEM

1. Internal Communication Challenges between Departments => Afterwards, we identified the issues, held open discussions, and refined our processes.
2. Control Hub Malfunction => Quick debugging revealed a loose wire connection, which we promptly fixed.

PERFORMANCE OVERVIEW

-4 out of 5 victories in the qualification matches => positioned us 13th in the ranking + being chosen as alliance partner by Cybermoon #19256.

-"3rd Place Alliance Partner"

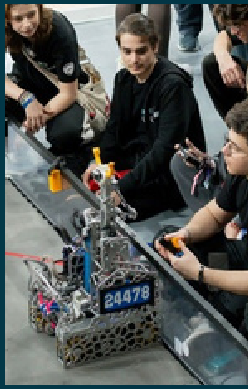
-"Control Award – First Place"

THE NATIONAL CHAMPIONSHIP

CHALLENGES AND HOW WE OVERCAME THEM

1. Very little time to prepare => Despite our early ordering, the components unfortunately arrived far too late, giving us only five days to construct a completely new robot, specifically designed to perform a level 3 ascent. => We spent every moment building, refining, and debugging — working day and night to bring our new design to life.
2. We were exhausted and under constant pressure => To manage stress, we supported each other, split tasks strategically, and stayed focused on progress, not perfection.

3.PTO Malfunctions: Because of the very little time to build our new prototype for the nationals, we faced a few technical difficulties, the main one being with the PTO, which led to other problems with the overall functionality of the robot. => At the National Championship, the robot still wasn't reaching the expected performance. Thus, after trying every way we could think of to solve the problems, we took a very risky move: to rebuild the previous version during the night between Day 2 and Day 3 of the nationals.



PERFORMANCE OVERVIEW

Finally, we managed to get the robot operational by the final day of the competition. Though we didn't achieve the peak performance we had originally aimed for, we walked away proud — not just of our technical progress, but of the unity, effort, and perseverance that defined our journey.

OUTREACH

ENGINEERDS

Reach = Number of participants aware of our moments/events + Social media engagement + Number of content views

The values shown as 'reach' represent statistics as of June 23, 2025.

STAYING CONNECTED

SOCIAL MEDIA

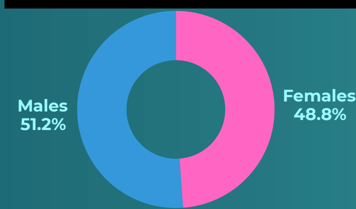
We use it to promote our robotics journey, engage with the community, and inspire the next generation of STEM enthusiasts through dynamic, creative content - from educational insights to funny, relatable moments.

CONTENT STRATEGY:

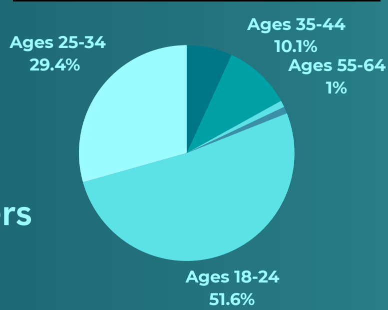
- Instagram & Facebook: professional and informative tone => sharing updates, achievements, and behind-the-scenes insights that reflect our growth and values.
- TikTok: fun and creative tone, using humor, trends, and relatable content to connect with the teenage audience => made us well-known in the Romanian FTC community.

AUDIENCE COUNTRY DISTRIBUTION

AUDIENCE GENDER DISTRIBUTION



AUDIENCE GENDER DISTRIBUTION



>850 followers
>52k views

>950 followers
>40k views

>560 followers
>6.5K views

PARTICIPATING IN "ORA DE EDUCAȚIE" ("EDUCATION CLASS") BROADCAST

- One of the most important broadcasts in our county.
- SHOW'S MISSION: to promote education, innovation, and personal growth => open discussions about the achievements of its guests.
- Two invitations
- Shared our journey—how our team was founded, how it has grown over time, and our long-term goals.
- Discussed how we welcome and support new members

Reach: 5165 Time invested: 1h30min x 2 = 3h

COMMUNITY OUTREACH

STREAMAGIA

- Partnership with "Constantin Brâncoveanu" Middle School
- May 21, 2025
- First off-season FTC demo ever held in our city
- Connecting with young STEM enthusiasts, middle schoolers participating in the NextLab Tech robotics competition — many of whom are just starting their journey in tech.
- Inspiring them to pursue this field => introduced them to FTC, showcased how a match unfolds, and explained the teamwork and engineering that go into building and operating a competitive robot.
- 5 FTC teams participated

Reach: 4780
Time invested: 6h30min

BOTSPARK PROJECT - MIDDLE SCHOOL VISITS

- Aimed to spread awareness for FIRST & motivate young students to explore technology
- Connected with middle schoolers and led them to want to join us in the future
- February 14 – 28, 2025
- Held robot and game demonstrations & open discussions
- Presented our progress and achievements

Reach: 11,508
Time invested: 1h x 3 = 3h

CREACTORS HUB

- Brought together technology and art through CreActorS HUB => event where LEGO robots became actors in theatrical performances inspired by traditional stories.
- May 15, 2025
- Support from LIDL & "Fund for a better future in communities"
- Made to connect students passionate about either robotics or theatre.
- Showed how robotics can preserve cultural heritage while making STEM more accessible, engaging, and meaningful.

Reach: 4315
Time invested: 4h

OPEN GATES DAYS

- Turning curiosity into passion, and visitors into teammates.
- In collaboration with our school – when tours are organized for 8th graders to promote our school, to have as many children as possible join our school in the following year / as independent initiatives
- Guiding students toward STEM
- Hands-on activities, live robot demos, and engaging discussions
- Introducing future volunteers to being part of an FTC team => two of them are now dedicated members

Reach: 2003 (August 2024 – Independently) + 3722 (May 2025 – In collab with our school) =5,725
Time invested: 3h x 3 days (August 2024) + 20 min x 28 classes of students (May 2025) = 18h20min

SUSTAINING SPORT IN LOCAL COMMUNITY
SPONSORSHIP OF THE NEXT GEN ATHLETES FOOTBALL CHAMPIONSHIP

- Important step in encouraging the establishment of such a long-term project in our city, Slatina.
- September 28, 2024
- Supported the idea of transforming the championship into an annual event
- OUR SPONSORSHIP: contributed to covering some of the organizational costs & promoting the competition.

Reach: 3096

TECHFEST

- Collaboration with the Student Council of our high school
- June 4, 2025
- Event dedicated to middle school students
- Engaged in interactive activities: experimenting with VR headsets & educational tablets
- Introduced them to both of our school's FTC teams
- Offered a complete overview of our activities — from robot design and programming to marketing, PR, and finance

Reach: 2708 Time invested: 2h

BUILDING BRIDGES

MENTORING AND ASSISTING - 2 TEAMS

- Mentoring EngiNeerds NextGen #25916 => the second team of our high school, founded this year
- Assisting Solar Sparks #25871 => the only middle school FTC team in Romania
- Helped teams all around the world (e.g. Kazakhstan)

Time invested: Mentoring – every day
Assisting – 45h+
Helping teams: whenever we could

RUNNING TECHTIDE OLTENIA MEET

- One of our goals for this season
- January 4 - 5, 2025, University of Craiova
- Collaboration with SoftHoarders #12560

Reach: 9 teams + 5,857
Time invested: 2 days

SUSTAINING GROWTH THROUGH KNOWLEDGE SHARING

- Internally: Design Guide for our non-technical department — a resource that helps unify the team's visual identity and supports recruits in PR and Marketing.
- Externally: FTC ATLAS (in progress) - a programming platform designed to assist the wider FTC community => GOAL: -providing an open-source documentation website that makes learning programming concepts easier and more accessible for teams from all around the world.

FTC ATLAS

LEGO WORKSHOPS FOR CHILDREN

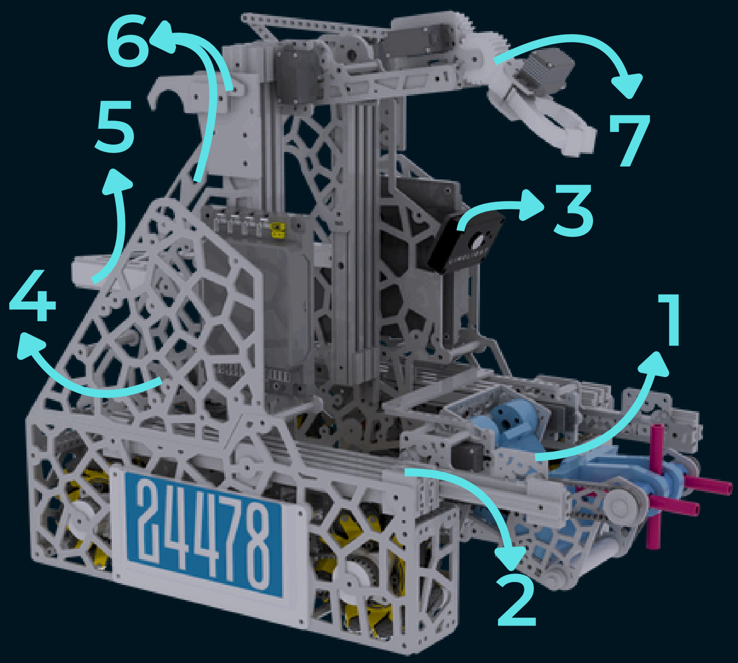
- Ongoing, engaging initiative for children passionate about STEM, from 6 years old and above.
- Every Sunday, since August 8, 2024
- Guiding them through the basics of mechanics and programming, fostering creativity and problem-solving through LEGO robotics.
- Reach: Beginning: 10 children => Now: 27 children from ages 7 to 12
- Laying the groundwork to create the first FLL team in our county
- SELF-TEACHING SYSTEM: We guide them through the resources they have to learn, whilst we are there for any questions they might have. Over time, they are taught how to self-learn from mistakes or by using technology, ensuring continuity in evolving, even when we aren't by their side.

Reach: 3057
Time invested: 2h x 35 sessions so far = 70h

DESIGN PHILOSOPHY

ENGINEERDS

PRESENTING LUX OUR SMARTEST, FASTEST, AND MOST RELIABLE ROBOT EVER.



KEY ROBOT PARTS

1. Intake
2. Horizontal slides
3. Limelight 3A
4. Aluminium pocketing plates to reduce weight
5. Specimen orientor
6. Fixed hooks
7. Outtake

ONSHAPE - FULL CAD STRATEGY

Our team uses PTC Onshape to design our robot - a Cloud-Based Software allowing online collaboration.

Before we build anything, we CAD the entire robot beforehand.

GOALS

- Reach a level 3 ascent
- Good cable management
- Consistent transfer process
- Absorb shocks during collisions
- Compact, as lightweight as possible (to gain more speed), and well-organized
- Resistant, fast, and reliable in actions
- Visually appealing design
- As simple as possible to program, remove points of failure
- Fast & reliable sample collecting & placement

COMMITMENT TO COMPACT DESIGN STANDARDS

A recurring theme in this portfolio is our dedication to compact design. Every part of our robot serves a specific purpose, and we aim to keep everything as organized as possible to ensure reliability. We've done our best to make this section of the portfolio as detailed as possible. However, if you have any questions, we are more than happy to answer them during the pit interviews.

ROBOT VERSIONS

HOW DID WE ACHIEVE OUR GOALS?

ENGINEERDS

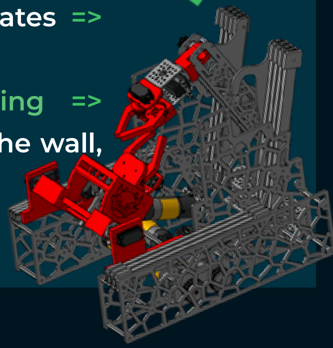
INITIAL DESIGN/LEAGUE MEETS (V1)

WEAK POINTS

- Long collecting process => The intake system's shape & complexity make for a long transfer/depositing sequence.
- The cable management wasn't the best => Lack of available space made the process of wiring our robot much harder & lengthier.
- The Control Hub and Expansion Hub weren't protected from collisions.

STRONG POINTS

- Fast lift and extension systems;
- Reached Level 2 Ascent => A set of stationary metal hooks makes a Level 2 Ascent possible.
- Control Hub and Expansion Hub placement allows for greater robot serviceability, whilst occupying little space.
- Open space for motors, cables, and outtake, but also not too crowded => diagonal slides in the back of the robot;
- Fast movement => Reduced weight => 3D printed main mechanisms (intake, outtake) & pocketed aluminium plates;
- Absorbing shocks during collisions => interior and exterior pocketed aluminium plates => the inside components are protected;
- Rapid & Accurate Specimen Placing => Outtake design permits intaking off the wall, as well as a high degree of freedom when hanging on chambers.



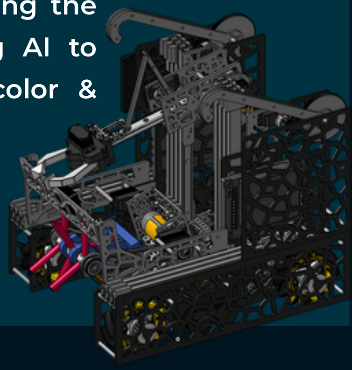
REGIONALS/NATIONALS DESIGN (V2)

WEAK POINTS

- Moments when the intake wasn't collecting samples properly or the transfer process failed, but these situations did not happen all the time;
- Couldn't reach a level 2 nor a level 3 ascent, which was our goal.

IMPROVEMENTS

- Much better transfer sequence => The slides are now vertical instead of diagonal
- Much better cable management => The robot now has a dedicated space for cables, on the back of the vertical slides
- More consistent transfer process => A viper slide was placed on the outtake instead of the claw support piece that made the past version's arm bend
- Consistent sample collecting => The intake system was designed to absorb samples from any orientation
- Faster specimen placing process => The Viper slide on the outtake
- Limelight camera => Allows the collection of additional samples from the submersible during the autonomous period, using AI to localize and detect the color & position of the samples
- Protection of Control Hub, Expansion Hub, and Servo Hub => Pocketed aluminium plate



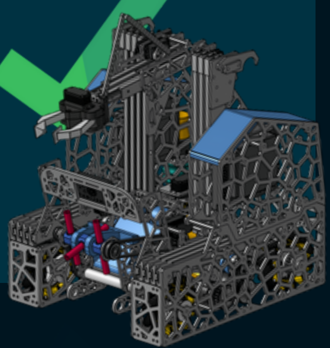
NATIONALS DESIGN (V3)

WEAK POINTS

- Couldn't achieve a level 3 ascent, despite the PTO that was added => in the designing process, the back side of the panels was placed at too high an angle, which did not allow the robot to pass over the first bar
- There were moments when the intake wasn't collecting samples properly

IMPROVEMENTS

- Longer extension => the chassis that was redesigned to be shorter, so that the horizontal slides were able to extend to the other side of the submersible;
- Much more resistant outtake => placed two Misumi SAR220 slides instead of one Viper slide;
- Faster and more consistent transfer process => 3D printed ramp placed inside the intake;- Faster movement => the chassis is shorter and lighter (14kg);
- -Everything V2 has



ACTUAL DESIGN (V4)

IMPROVEMENTS

- A more compact design => the motor that powers the horizontal extension is positioned horizontally.
- It can achieve a level 3 ascent => redesign of the back side of the plates.
- Everything V3 has (except for the intake ramp that was removed during the redesign)

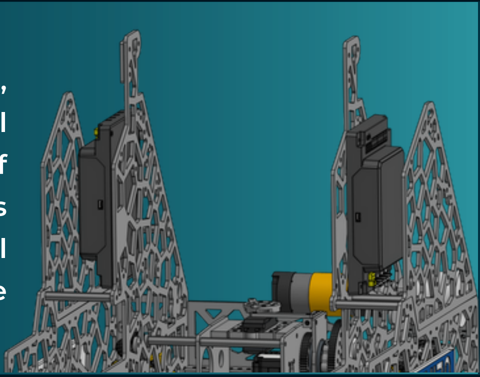
DRIVETRAIN

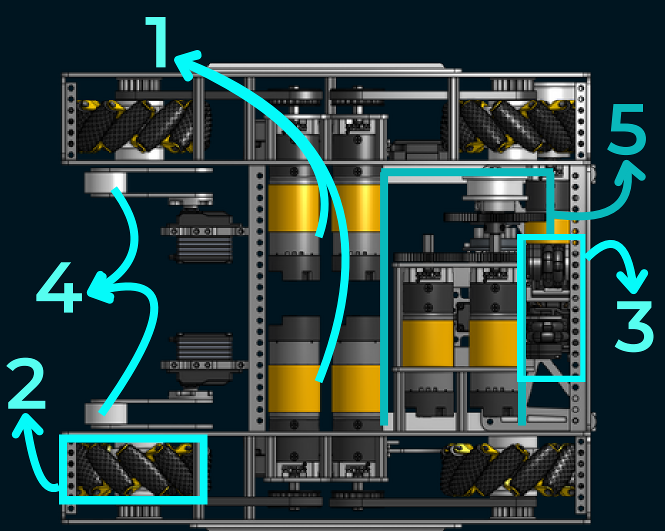
SHORTER IS BETTER

As mentioned earlier, we shortened the chassis by 3 cm in length (from 41 cm to 38 cm) => increase speed & make room for a new set of Misumi SAR230 slides on the extension system.

STRATEGIC HUB PLACEMENT

For both protection and easier debugging, we strategically positioned the Control and Expansion Hubs on the outer sides of the robot. This placement provides excellent accessibility to all internal components while keeping valuable interior space for mechanical systems.





KEY COMPONENTS

1. x4 435 RPM motors, each being connected to the wheels by two 3D-printed gears and a belt
2. Mecanum GripForce Wheels
3. 4-Bar Odometry Pods
4. Hanging legs used for level 3 ascent
5. Gearbox used for level 3 ascent

GOING FASTER

Going from a 24:22 gear ratio to a 24:20 ratio, the new model reaches up to 549 RPM (from 509 RPM), although the risk of power loss still remains.

To ensure that the gear ratio was appropriate for the target speed of the drivetrain, we verified the gear ratio using the following calculation:

Input gear : 24 teeth Output gear : 19 teeth ⇒ 0,79 : 1 Ratio

Input speed : 435 RPM ⇒ Output speed = 435 : 0,79 ≈ 550 RPM

$$\text{Speed (m/s)} = \frac{\text{RPM} \times 2 \times \pi \times \text{Wheel radius}}{60}\text{ ; Wheel radius in meters}$$

$$\text{Gobilda GripForce Wheel radius} = 52\text{ mm} = 0{,}052\text{ m} \Rightarrow \text{Speed} = \frac{550 \times 2 \times 3{,}14 \times 0{,}052}{60} \approx 3\text{ m/s or } 10{,}8\text{ km/h}$$

$$\text{Linear acceleration} = \frac{S_1^2 - S_0^2}{2 \times d}\text{ ; L.a.} = \frac{3-0}{2 \times 2} = \frac{3}{4} = 0{,}75\text{ m/s}^2\text{ or } 2{,}7\text{ km/h}^2$$

S_0 - initial speed = 0 m/s S_1 - final speed = 3 m/s   d - distance until final speed is achieved = 2 m

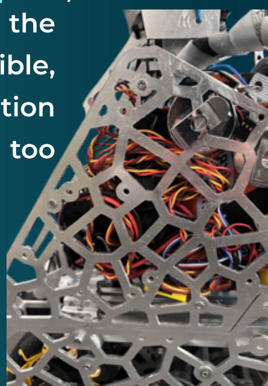
CABLE MANAGEMENT

CABLE SLEEVE STRATEGY

We wanted to route the cables neatly throughout the robot, to occupy as little space as possible and also to avoid tangling => We make use of cable sleeves, in which we place all available wires.

IN-BETWEEN PLATES STRATEGY

The placement of the Hubs on the interior plate leaves room between the Hubs and the exterior plate, which we use to fit as much of the cables' length as possible, taking into consideration not bending them too much, and risking breakage.

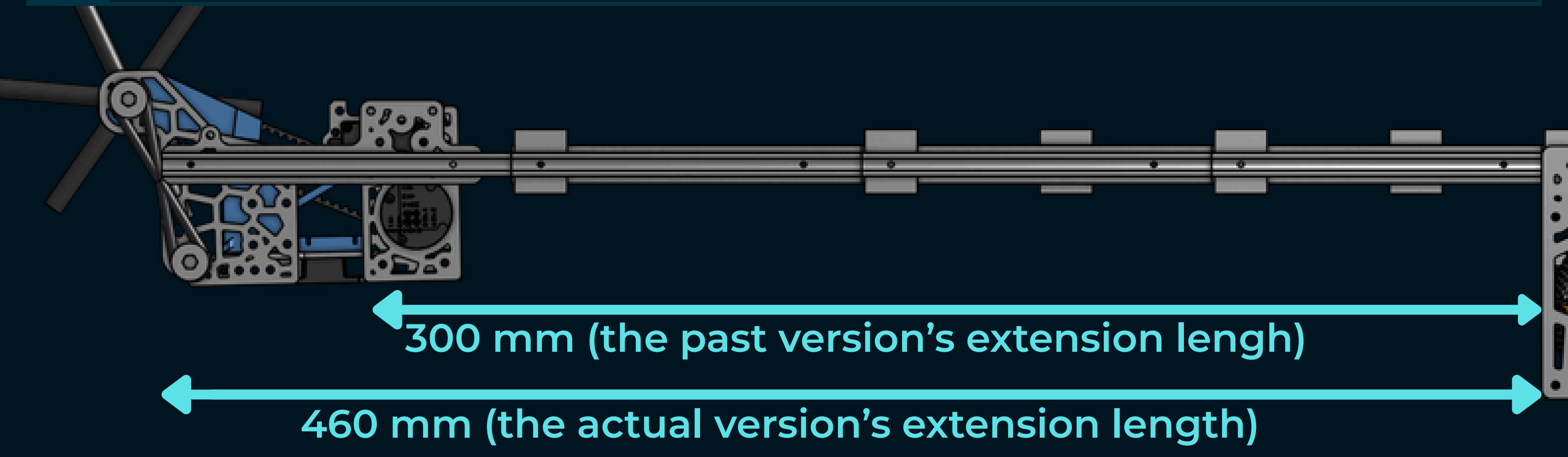


OUTCOMES OF WELL-THOUGHT-OUT CABLE MANAGEMENT

- Prevents disconnects & short-circuits (ex., servo-clippers)
- Prevents potential wire/cable flameout through hardware limiters (ex., robot's extension is limited by the length of the cable)
- All cables & hub ports are readily available, making debugging issues easier

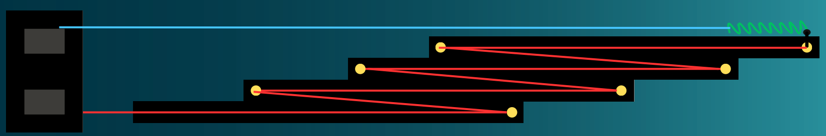
EXTENSION SYSTEMS

Goal: to achieve a fast and robust extension system that also doesn't occupy too much space between the plates.



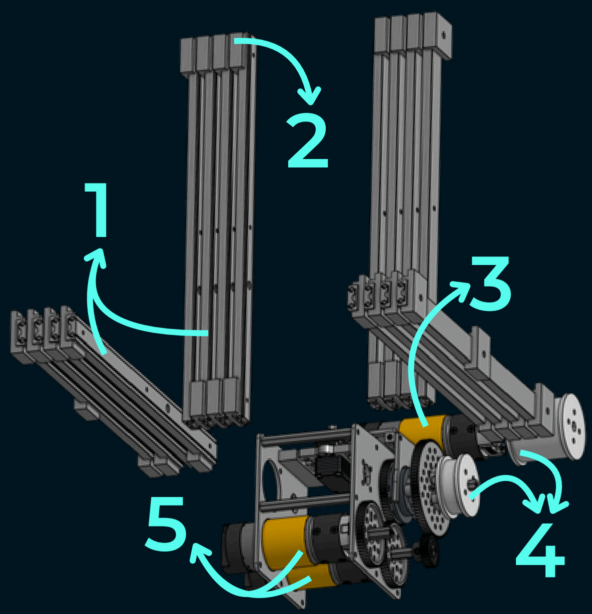
HOW DO THEY WORK?

There is a double spool containing both the retraction string and the extension string. The retraction string stretches the spring attached to the last Misumi, while the extension string is pulled onto the spool and then through the pulleys in the inserts, causing the slides to extend. The slides extend in the opposite direction of the retraction process.



KEY COMPONENTS

1. x2 x4 Misumi SAR230 slides
2. Metal inserts which hold the string
3. x1 1150 RPM motor that powers the horizontal slides
4. x2 40 mm spools that hold both the strings
5. x2 1150 RPM motors that powers the vertical slides through a gear system



PROBLEMS & SOLUTIONS

a) Metal Inserts:

To connect the slides, we use metal inserts instead of 3D-printed ones, as previous versions often broke under high pressure. The metal inserts offer significantly greater durability and reliability.

b) String:

Initially, we used a 1 mm fishing line rated for up to 150 kg, but it frequently snapped due to the stress placed on it during operation. To improve durability, we upgraded to a stronger 0.9 mm string that supports up to 159 kg.

ASCENT SYSTEM

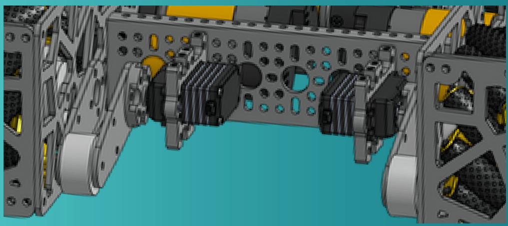
PROBLEMS ENCOUNTERED IN OUR ITERATIONS

- Two bare motors that power the slides / Metal Hooks, powered by Axon MAX+ servos: not enough power
- PTO: Having so many motors running at the same time caused our robot to have an abnormally high current draw.

SOLUTION
3 MODULE SYSTEM

THE HANGING LEGS

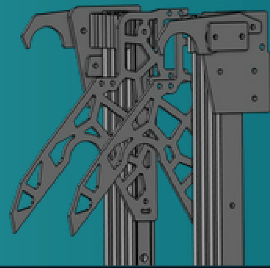
They push the robot upwards to a 30-degree angle relative to the ground, making it easier to complete the hooking process.



HOOKS

Small Hooks (Cord-Actioned) – These are fixed and positioned at the end of the vertical sliders. They can only move downward, allowing them to pass the first bar and release the larger hooks, which will complete the attachment to the second bar.

Large Hooks – Positioned on the last set of vertical sliders, they enable hooking onto the second bar. After the large hooks attach to the first bar, the small hooks take over the support of the robot on the first bar, allowing the large hooks to complete a level 3 hang.

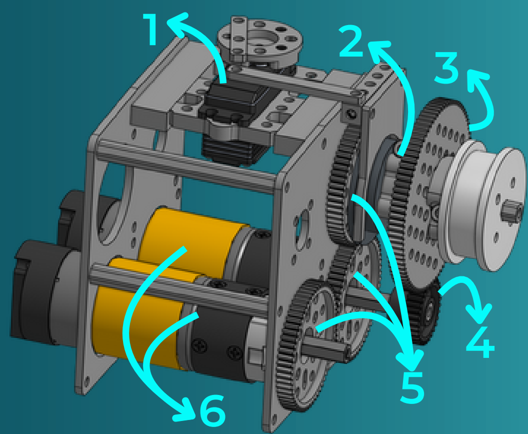


DESIGN SPOTLIGHT - GEARBOX

We implemented a system that allows the motor input to switch between two different gear outputs. The first gear system, used for vertical extension, has a 1:1 ratio, maintaining the motors' original speed of 1150 RPM. The second system, used for ascent, features a 1:5 gear ratio, which significantly reduces speed but greatly increases torque.

KEY POINTS

1. Axon MINI+ that actuates the gear shifter through a linkage
2. Gear shifter
3. 100 tooth gear
4. 20 tooth gear
5. 60 tooth gears
6. x2 1150 RPM motors



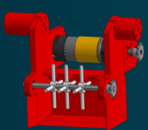
INTAKE & OUTTAKE
ITERATION PROCESS

ENGINEERDS

QUALIFIER 1

Feedback: 50% consistency collecting – placing

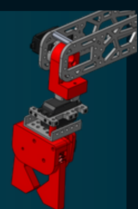
INTAKE



Intake V0 - This is the first prototype of the intake. We noticed that it regularly had issues with repositioning samples.

OUTTAKE

Outtake V1.1 – it sometimes had problems with the grip on the sample during transfer because of the shape of the claws.



QUALIFIER 2

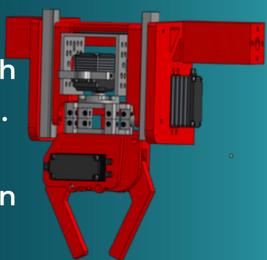
Feedback: 70% consistency collecting - placing

INTAKE

Intake V1 - We switched to a model with a claw to ensure stability and precision of the caught sample, which was positioned vertically.

Weak Points:

- Intake requires a high amount of driver precision.
- High chance of failure.
- The 3D printed design isn't very robust.



OUTTAKE

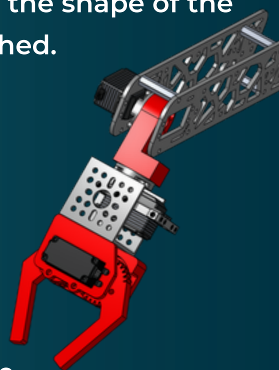
Outtake V1.2 – This model was made to be more effective by making the arm longer and changing the shape of the claw fingers to be slimmer and more arched.

Strong Points:

- Stability of the sample
- Fast specimen placing => outtake could take the specimen from the wall without turning 180 degrees, and also to place it from a greater distance;

Weak Points:

- Did not fit the third version of the intake.

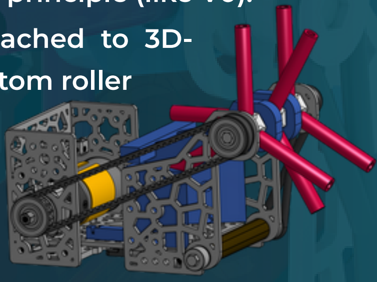


REGIONALS + NATIONALS

INTAKE

ABSORPTION PRINCIPLE – ULTIMATE SOLUTION

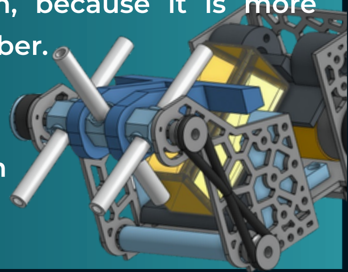
Intake V2.1 - When we rebuilt the robot, we switched to the absorption principle (like V0). It used silicone tubes attached to 3D-printed supports and a bottom roller made from rubber placed around the shaft, in order to have adhesion and make the sample slide into the compartment.



Intake V2.2 - We added a 3D printed ramp for the consistency of the transfer, the other change being in the material used for the bottom roller, going from rubber to cast silicon, because it is more resistant to friction than rubber.

Key Points:

- Easier sample collecting
- Durability due to aluminum body



OUTTAKE

SIMPLER IS BETTER!

Outtake V2 - This version doesn't have a servo that spins the claw 180 degrees, because we noticed it was pointless in making the transfer and placing process faster. We also made claw fingers more arched. It was made for the actual intake, so that the transfer of the samples between the intake and the outtake could take place easily.

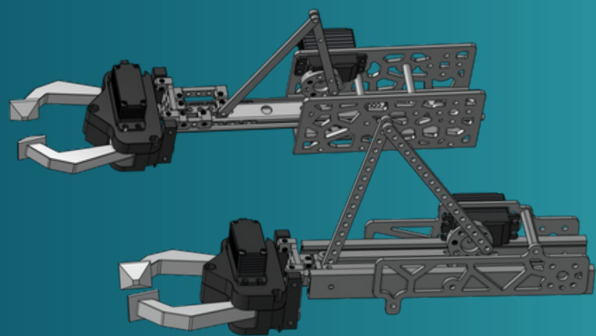
Outtake V3.1 - This version initially used a Viper slide, then two Misumi SAR220 slides, placed on a metal support, with the claw attached on top through a quad block. The slides were moved by a linkage-type mechanism.

Key Points:

- Much more efficient system => it makes the arm extend based on the task,
- The claw's pyramidal tip allows the robot to hook specimens from any orientation and at a greater distance
- Reduced the need for such high dexterity from the drivers.

VIPER SLIDE VS MISUMI SAR220 SLIDES – WHY IS MISUMI BETTER?

1. Length – Misumi slides are shorter than the Viper slide, which allows us to fit within the pre-established dimensions set in the Competition Manual more easily.
2. Efficiency - Misumi slides move more smoothly and put less strain on the Axon MAX+ servo that controls them.



Feedback: 75% => 95% consistency collecting – placing

CRI

INTAKE

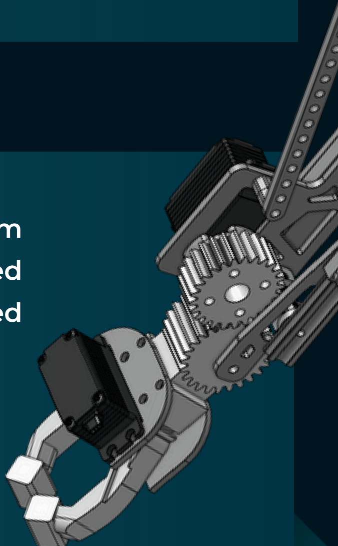
Intake V2.2 – We kept this version because it functioned really well at the nationals.

OUTTAKE

Outtake V3.2 – The only improvement made is the gear system that connects the slides to the claw support. Also, we changed the shape of the claws to fit the shape of the newly designed intake and have a good grip on the sample, too.

Key Points:

-Enhances the outtake's functionality by making the claw support => much more consistent transfer process.



Feedback: 95% consistency collecting – placing

SOFTWARE & SENSING

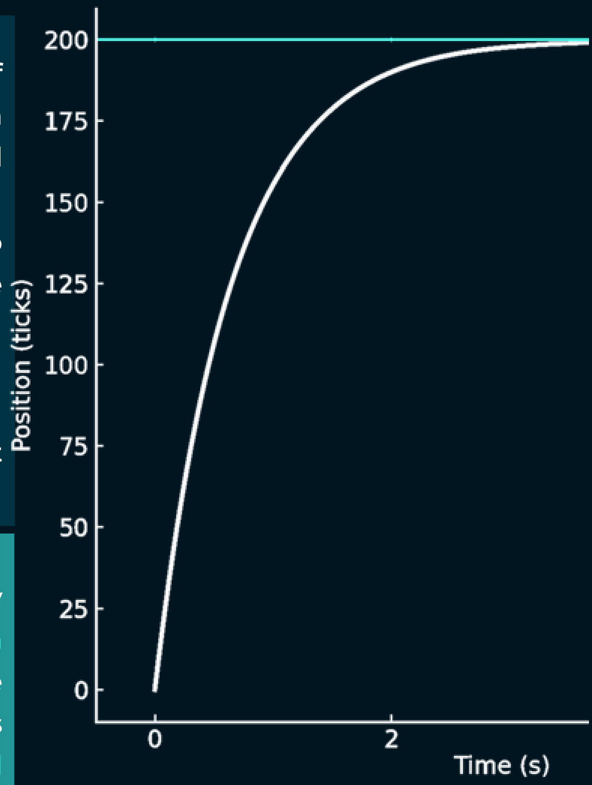
CLOSED-LOOP CONTROL

PID CONTROL

Proportional-Integral-Derivative Controllers (PID) are the core of FTC closed-loop control. Simply put, they help the robot maintain target positions by constantly adjusting the motor power level based on encoder feedback.

Through PID control, motors can move precisely and reliably to target positions, whether it's the lift, extendo, or drivetrain. The controller adjusts power using three tuned terms:

- Proportional (P), which reacts to how far off the target you are.
- Integral (I), which accounts for past error over time.
- Derivative (D), which acts as a damper by looking at the current position's rate of change.



VOLTAGE COMPENSATION

PID output can, at low battery voltage, result in wonky movement. To counter this problem, we compensate by adding a scaling factor that scales the output based on the ratio of the battery's nominal voltage (12V) to the current voltage. This ensures that subsystems making use of PID control loops respond consistently regardless of battery level.

! "Zeroing" means resetting a sensor to its neutral value once a specific action has occured.

VOLTAGE-BASED ZEROING

Encoder zeroes out (resets neutral position) once the lift motors' current draw is higher than a specified threshold.

VELOCITY-BASED ZEROING

Similarly, the encoder zeroes-out once the extension motor's velocity reading is close to, or equal to 0 for a specific amount of time.

✔ Through zeroing, we nullify any and all encoder drift accumulated during the game.

OPTIMIZING LOOP TIMES

Loop times in this context refer to the frequency at which a loop updates/sec (e.g., a 100Hz loop corresponds to an average of 10ms between iterations).

WHY SHOULD I CARE?

Naturally, a faster update rate allows PID controllers and gamepad inputs to sample more frequently, resulting in smoother driver control and subsystem movement.

POWER & POSITIONAL CACHING

To reduce redundant motor writes, we've created a custom motor class that caches both power and position values. Updates are only sent if the new value differs from the previous one by more than a specified threshold.

SENSOR THROTTLING

Similarly, we throttle the rate at which our color sensor gets polled. I2C reads on the Control Hub can take around 4ms **per call**, so reducing the frequency by ½ significantly improves loop times with little cost to responsiveness.

BULK-READING THE CONTROL HUB

At the start of every loop iteration, we bulk-read the Control Hub. This gets all hardware data at once, preventing any additional calls from having an impact on loop times.
Due to the low number of additional sensors on our robot, we only need to bulk-read the Control Hub. Since there are no sensors in the Expansion Hub, bulk reading it would be completely unnecessary.

✓ Thanks to these optimizations, our loop times have significantly improved compared to our previous robot. During the driver-controlled period, we average around 100Hz, while autonomous runs at approximately 90hz!

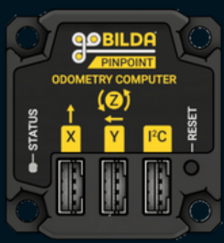
DRIVETRAIN CONTROL

ENGINEERDS

FIELD LOCALIZATION

Our robot localizes itself on the field through the use of odometry pods connected to the goBilda Pinpoint computer. This co-processor runs positional calculations independently from the Control Hub, at approximately 1500hz (1500 calculations per second), thus ensuring precise localization on the field. The pinpoint also contains what's known as an IMU (Inertial Measurement Unit). We use the IMU's gyroscope function to measure the robot's heading on the field.

An odometry pod is a non-actioned wheel (dead wheel) with an encoder that measures robot movement on a specific Cartesian axis (x/y).



FILTERING VALUES

Encoder readings go through what's known as a Low Pass Filter (LPF). An LPF smoothens out values by damping sudden changes, preventing jitter.

CUSTOM FOLLOWER

During the season, we made use of the RoadRunner 1.0 motion-planning library for our autonomous movement. RoadRunner, while accurate for most use cases, is not the fastest option available.

To improve speed and allow for more customization, we developed a custom follower based on a PID-to-Point approach. This system uses three independent PID controllers to manage the robot's position along the x and y axes, as well as its heading angle.

PROBLEM

Even with adequate PID tuning, the robot stopped and accelerated way too abruptly. This resulted in janky movement & wheel slippage at the start & end of paths.

SOLUTION

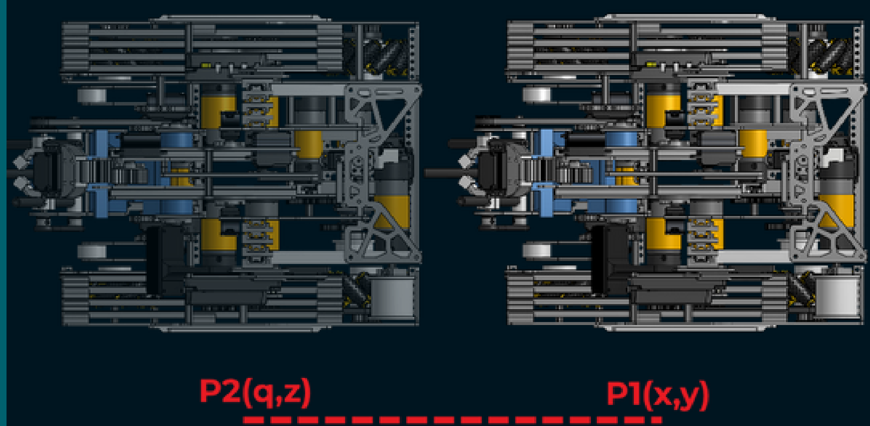
Implement a predictive deceleration system into our custom follower

PREDICTING STOPPAGE DISTANCE

To avoid sudden braking and overshooting, we predict how far the robot would coast if it suddenly stopped applying power:

$$d = \frac{{v_0}^2}{2}$$

This uses basic physics, applied separately to both axes. We then convert field-relative velocity into robot-relative, apply deceleration constants, and then rotate the result back into field-centric.



Robot pre-emptively applies the power level necessary for stoppage at point P2, whilst actually being at point P1.

A Bezier curve is a parametric curve defined by a set of control points. It allows for smooth motion. The robot's path & heading are influenced by the position of these points, allowing for greater control.

BEZIER CURVE FOLLOWING

Sometimes it's faster & easier for the robot to move along a smooth curve rather than a series of straight lines (i.e., when going towards the submersible from the basket).

We've implemented a Bezier Curve follower that allows our robot to follow curved paths. The follower calculates intermediate target points along the curve, resulting in more fluid and continuous movement.

DESMOS VISUALIZER

To support path creation, we've also built a custom Bezier curve generator in Desmos. This tool lets us visually design curves by moving the control points around and instantly seeing the result!

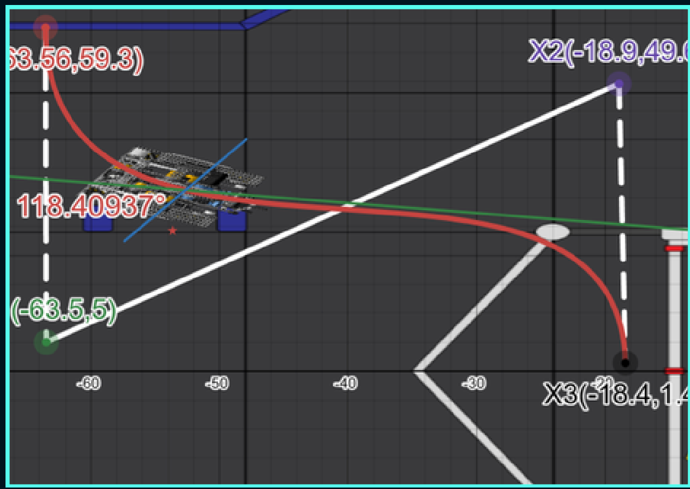


Image of the Desmos visualizer

PINPOINT FAILURE PREVENTION

In order to prevent wrong values being fed into the positional PID controllers, we check for big discrepancies between the position of the robot, recorded by the pinpoint, and the previous position. If, for example, the difference in heading is over 50 degrees, we reset the pinpoint to its previous position.

CAMERA VISION

ENGINEERDS

DETECTING SAMPLES

We make use of the Limelight 3A camera, running a neural detector pipeline, in order to detect samples. Our detection model is trained on 3000+ images of ITD samples. This is both easier & more reliable than using OpenCV, as the detection doesn't react as much to changes in lighting.

ESTIMATING POSITIONS

Once a sample is detected, we estimate its position using the LL's horizontal and vertical offsets (tx,ty). Taking into account the camera's angle, height, and physical offset from the intake, we determine the X and Y displacement of the sample. This way, we compute the angle and distance to the object.

$$extendoPos = \frac{d}{2\pi r}G$$

CALCULATING EXTENDO TARGET

After estimating the sample's distance, we convert it into motor encoder ticks. Using the known spool radius and the encoder resolution of the motor, we calculate how many ticks correspond to the required extension length. This lets our intake extend to the correct position with little-to-no room for error.

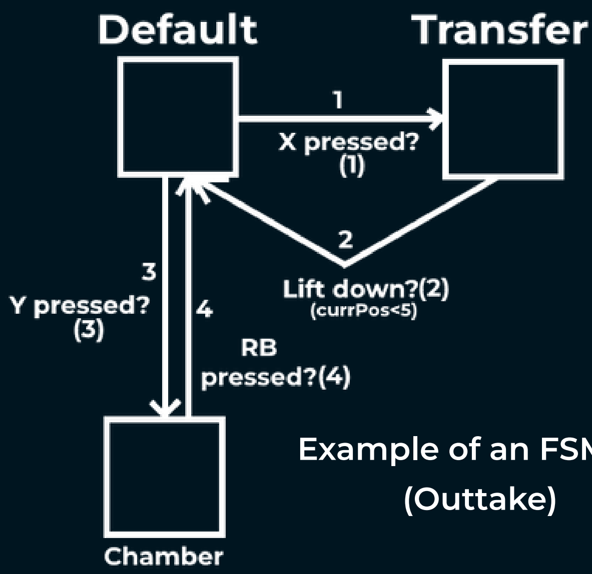
*Where d = Distance to sample (inch) r = Extendo spool radius, G = Motor Encoder Resolution

CODE STRUCTURE

SYSTEM STRUCTURING

All important robot systems, such as the intake or the outtake, are organized in separate classes that can be used in both Autonomous and TeleOp. Likewise, smaller parts of the robot are organized into subsystems, like the Extendo or the outtake's linkage.

The systems are Finite State Machines (FSM), running specific actions (i.e. running the transfer sequence) once set to a specific state. In this way, we can run multiple systems in parallel without additional hassle.



Example of an FSM loop
(Outtake)

TASK SCHEDULER (AUTONOMOUS)

During autonomous, systems get their states changed through a custom task scheduler. A task is comprised of four parts:

- A Java Runnable action that determines what exactly gets run when the task is called.
- An exit clause, which determines when exactly the task is complete.
- An "Exit" Runnable, which runs after the exit clause is fulfilled.
- An "Exit" Task, which runs after the exit clause is fulfilled.

The scheduler's role is to change tasks once the exit clause of the current task has been fulfilled. This makes our code easy to understand and allows for much easier debugging.

TELEOP AUTOMATIONS

AUTO SPECIMEN PLACEMENT VIA LOCALIZER

We make use of the follower during TeleOp in order to automatically pick up & score specimens. The driver resets the Pinpoint's position once the robot touches the wall. After pressing another button, the driver can simply watch how the robot places specimens on its own. This mitigates driver errors and bad movement, whilst also having a high degree of accuracy.

ONE-BUTTON ASCENT

Our L3 Ascent is fully automatic & only takes one button press. In order to hang onto the second bar, we measure the pitch of the robot from the Control Hub's internal IMU. This lets the robot naturally swing and hook onto the bar using its momentum, without the need for extra driver control.

SAMPLE COLOR DETECTION

Using a REV Color Sensor V3, the intake automatically spews out wrongly-coloured samples. Otherwise, if a correctly-coloured sample is detected, the robot automatically initiates the transfer sequence.

VIBRA-QUEUES

Both controllers vibrate when there are 20 seconds left in the match. This alert also acts as a backup in case a sample enters the intake, but the color sensor fails.

This portfolio was created and written entirely by the EngiNeerds team. To improve clarity, structure, and wording, AI-based tools such as ChatGPT were used as writing aids. All technical content, design decisions, and engineering solutions were documented, tested, and developed by our team members.