FIRST TECH CHALLENGE ROMANIA | INTO THE DEEP | 2024 SEASON #9 2025 | ORGANIZATOR NAȚIE PRIN EDUCAȚIE | PARTENER FONDATOR BRD GROUPE SOCIETE GENERALE

High Five 19049

Engineering Portfolio

2024-2025

Team Overview:

Our team's structure:

- 18 members: 15 members & 3 volunteers;
- 9 girls & 9 boys;
- Ages from 13-18;
- From 6 different schools.

Leadership roles:

- 1 Team Leader;
- 2 Technical Leads;
- 1 Non-Technical Lead.

Departments:

- CAD & Mechanical;
- Programming;
- Digital Design & Marketing.

4 Mentors, 2 Assistents & 1 Alumnus that helped and guided us throughout this season.

Donkey

Our **43 Week** Creation, Presented by **Team High Five 19049**

Highlights:

THINK AWARD

We have developed a **detailed and rigorous Design Process,** with a heavy focus on **previous iteration analysis** based on the feedback given **by Ravi Prakash, engineer at NASA JPL**.

CONNECT AWARD

- We focused a lot on **member skill development** - through events, workshops and usage of new methods, team members managed to evolve and get new knowledge;
- We have impacted over **7000 people** from our **local community** and interacted with **176 national & international teams** from **all 3 *FIRST*® programs;**
- We have interacted with over **800 specialists** in the **engineering community.**

MOTIVATE AWARD

From the beginning of the season, we've created a season plan, so that we have:

- implemented multiple **team workflow tools;**
- **€51 000** in sponsorships for this season and over **€20 000** already for the upcoming season;
- managed our biggest impediment yet as a team, being that 17/18 members were in their first 2 years;
- **mentored 4 teams,** donated over **€4 000** in parts and **helped 10 teams** during the championships hosted in our city;
- **recruited 33 people** as volunteers for our team;
- participated in **40 events**, with an outreach of **7000 people.**

DESIGN AWARD

We have spent over a month in the designing part of our latest robot's creation, having **multiple review sessions** where **all members** of the technical department took part, and we have managed so that every part of our robot is carefully thought out and **every unnecessary component was removed**.

INNOVATE AWARD

We have a **unique** Servo powered Intake mechanism, that can collect from **two different positions** and in **4 ways,** to ensure driver's ease of use and to minimize the drawbacks of using an Active Intake for **Specimen** play, whilst maintaining the benefits for the **Sample** side.

CONTROL AWARD

We use a total of **9 sensors** on our robot to help us in the Auto period and throughout the **TeleOp** for faster actions. With their help, we have **developed** a total of **3 automatizations** and a lot of **sequences.** With our **Trajectory** and **Localization Algorithm SPEEDI,** and also our **software architecture,** we have managed to remain **consistent**.

MOTIVATE & CONNECT AWARD

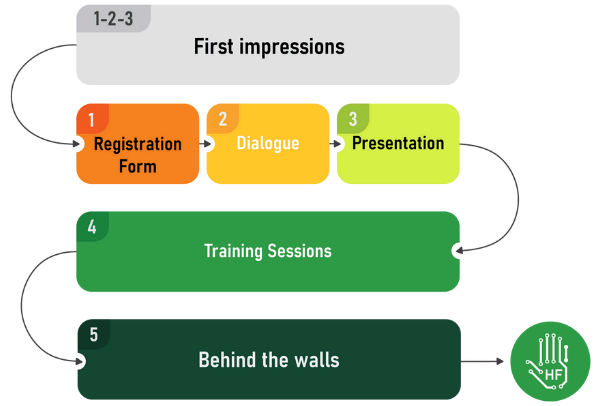
Recruitment Strategy:

This year, the recruitment strategy we adopted had the following objectives:

- Getting to know the new volunteers;
- Knowledge transfer;
- Testing teamwork skills.

Following the **4 recruitment sessions** held since the 2024 OffSeason (April 2024), we've had:

- **33 volunteers** from **9 different schools;**
- Out of these, **8** became **team members**, and **3** are still with us as **active volunteers.**



Member Development Plan:

Being in a period of transition, this season we are focusing on the development of our members. Some of the methods we used:

- **Pass-on** (knowledge transfer between generations);
- **Workshops and conferences** (both technical and non-technical);
- **Discussions with specialists;**
- **Brainstorming sessions.**

Risk Management:

This season, the main challenge was the **high number of members with limited experience** (17 out of 18 members are in their first 2 years of activity). To facilitate both the work and the learning process, we implemented several effective solutions, including:

- The use of **intuitive and user-friendly resources;**
- Transition from Adobe InDesign to Canva, due to its user-friendly interface and real-time collaboration features;
- In the Hardware department, we opted for using **standard parts**, which are accessible to all members regardless of their level of experience.

Objectives:

Some of the objectives we've managed to achieve:

- **Having over 20 events & projects** - we managed to have over **40 events** in the span of 15 months, doubling the number we initially set as an objective, impacting over **7000 people** from our community;
- **Obtaining revenues of at least €35 000 for the European Premier Event** - we managed to reach revenues of around **€51 000** - enough to cover our expenses for this journey;
- **Rebuilding our robot with more complex pieces, reducing its weight** - through the year we've evolved and learnt new things, now having a total of **108 custom pieces** (73 pcs. of PLA, 12 polycarbonate pcs., 23 Aluminum plates). From the 19kg we had at Nationals, the robot for the European Premier Event has 18kg.

Work in progress **objectives**

- **Strengthening relationships with teams from *FIRST®* programs** - we want to interact with as many teams from the *FIRST®* programs as we can. Trough our **International Hub project**, we've met with **over 50 teams from 17 countries**, carried out over the last 8 months and still going;
- **Continuity of our team** - every year we organize different **Recruitment Sessions** so that we are in a continuous learning process, with new members and volunteers coming every year. This season we've had **33 volunteers** (a record for our team), of which **8** became **members** and **3** are **active volunteers.**

MOTIVATE AWARD

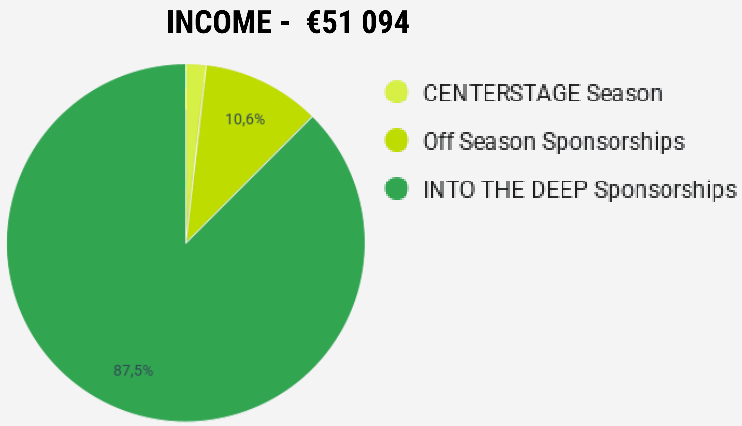
Finances:

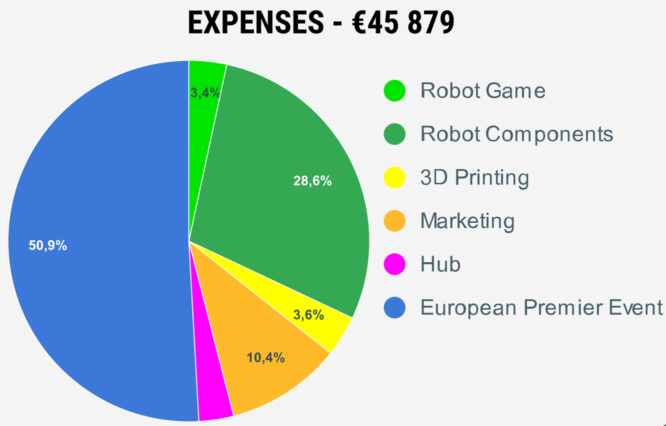
This year, we focused on **financial sustainability**, implementing several methods to efficiently manage our income and expenses, including:

- We tackled our expenses responsibly, maintaining **open and transparent communication** with sponsors and partners to show how we use the resources provided;
- We developed a **strategy** to attract new sponsors and partners while strengthening relationships with existing ones, communicating through **emails** and **presenting our progress.**

This year we've also created a **sustainability plan for our revenues**, at this moment having **money saved up** for the 2025-2026 season or for unexpected expenses.

50 Sponsors & 4 Partners

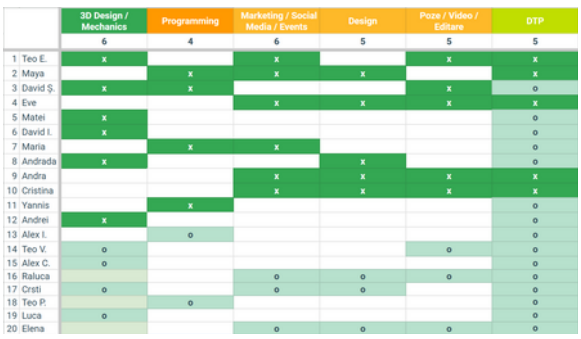




Organization:

Weekly meetings - these are the first steps in communication, analysis and resolution or in the formation of the other documents we use (Season Timeline, Main Role & Support etc.)

Season Timeline 2024-2025 INTO THE DEEP - by using it we are able to visualize the season, present each week, and establish our goals or events that we have.

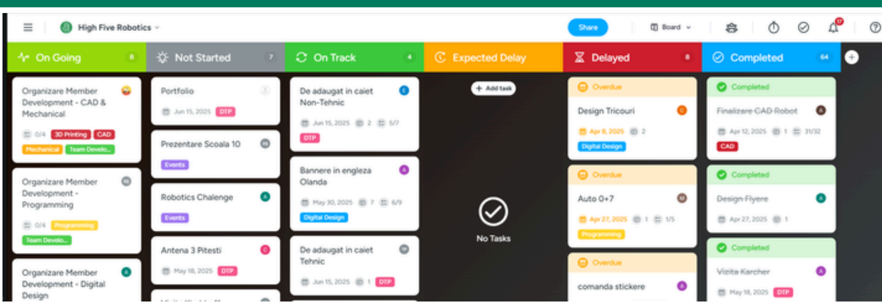


		3D Design / Mechanics	Programming	Marketing / Social Media / Events	Design	Poze / Video / Editare	DTP
		6	4	6	5	5	5
1	Teo E.	x		x		x	x
2	Maya		x	x	x		x
3	David Ș.	x	x			x	o
4	Eve			x	x	x	x
5	Matei	x					o
6	David I.	x					o
7	Maria		x	x			o
8	Andrada	x			x		o
9	Andra			x	x	x	x
10	Cristina			x	x	x	x
11	Yannis		x				o
12	Andrei	x					o
13	Alex I.		o				o
14	Teo V.	o				o	o
15	Alex C.	o					o
16	Raluca			o	o	o	o
17	Crsti	o		o	o		o
18	Teo P.		o				o
19	Luca	o					o
20	Elena			o	o	o	o

Main Role & Support - Shadowing & Role Transfer - this year we are going through a transition phase, so through the **Support process**, correlated with the **Shadowing process**, we manage to achieve the transfer of tasks, skills and experiences, in the smoothest, easiest way possible.

Google Workspace - we use Google Workspace because it allows multiple users to work on the same project simultaneously. Also, over the years, Google Drive has become the team's archive, easily accessible.

MeisterTask - it allows us to keep our planning clear, maintaining a shared overview of progress, responsibilities and deadlines - making collaboration more efficient and goal-oriented.



Outreach:

MOTIVATE & CONNECT AWARD

This year, through our events and projects, we managed to interact with approximately **7000 people**.

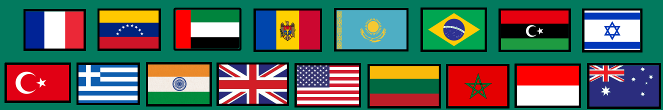
40 Events & 4 Projects

Our main 4 projects from this season, but also some impactful events:

International Hub

November 2024 - June 2025

Over the course of 30 weeks, we had the opportunity to interact and collaborate with **52 teams** from **all 3 *FIRST*® programs**. The teams were from all around the globe - **17 countries & 6 continents**.



GODMOTHER

October 2023 - June 2025

The concept of this project was born from the previous season, when we set out to support the formation and development of new teams.

We are mentoring **4 international teams** - 2 from Romania, 1 from India and 1 from the UK, **donating robot pieces worth around €4000** to one of them.

Atlantykron

August 2023 - August 2024

Here we've had **2 workshops**, impacting **20 young adults & children**. Throught the camp we've interacted with over **160 experts & people** from 11 countries.

Hide & Meet 2025

January 2023 - January 2025

We've organised a League Meet in colaboration with **3 other teams**.

The event had an outreach of over **2 500 people**, interacting with **19 other teams** and having **36 volunteers**.

This project it's on its 3rd annual edition!

Events in shopping centers

What we've managed to achieve through these **5 events in shopping centers** include:

- Collaborated with **7 other teams;**
- Over **500 attendees of all ages** engaged with robotics ;
- Strengthened the **public – *FIRST*® community connection**.

Schools visits

Following this season's visits we managed to:

- Visit **3 high schools** and **2 middle schools;**
- Interact with a total of **560 students.**

The robot demonstrations and new information captivated students, **many of whom joined us as volunteers**.

Outreach Overview:

Trough the **40 events** and **4 main projects** that we've had this year, we've managed to:

- Reach approx. **7000 people** from our local community;
- Interact with **different experts** - direct interaction with over **800 experts;**
- Help with the **skill development** of our members;
- Have **national & international connections** with **176 teams** from the *FIRST®* programs.

2620h for events & 1058h volunteering

MOTIVATE & CONNECT AWARD

Connecting with the Engineering Community:

This season we managed to **interact with the engineering community** through **14 key events**, having the chance to talk to **800 specialists**.

Some of the things we've learnt / improved from these interactions:

- Public speaking & connecting with an audience;
- How the STEM phenomenon has impacted the education system;
- The importance of different materials and how to use them;
- 3D Printing - do's and don'ts;
- The impact of the business world on everyday life.

Atlantykron
160 specialists

National Olympiad
120 specialists

Virtual Factory
80 specialists

Polifest
400 specialists

Workshops with college professors (2 workshops)
3 specialists

14 specialists
Visits in different companies (7 visits)

European Researchers' Night
25 specialists

Member Skill Development:

This year, our team is predominantly made up of **people in their first 2 years of *FIRST*® Tech Challenge**, one of our main goals from this season being the **continuous development of our members**.
Thus, as we are going through a period of transition, throughout the season we have participated in **7 events** through which we can ensure the development of our members, regardless of seniority or department.

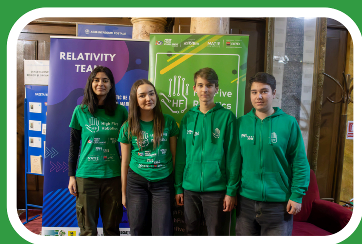
Some of the things we've learnt / improved from these interactions:

- Training sessions with our mentors & assistants;
- Public speaking & connecting with an audience;
- The importance of non-verbal and paraverbal communication;
- How the STEM phenomenon impacts everyday life.

Atlantykron

Training sessions with our mentors & assistants

STEM conferences



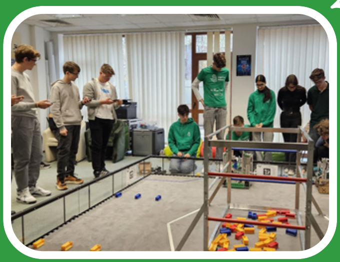
Workshop about communication

Workshop on Robotic Process Automation (RPA)

MOTIVATE & CONNECT AWARD

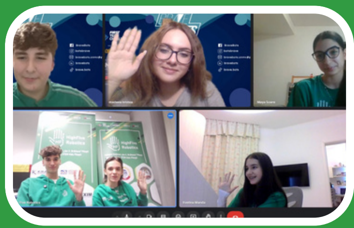
Better Together:

This year we had **14 events and projects** dedicated to the **Better Together** section, in which we collaborated with other teams and strengthen relationships with them, managing to interact and impact over **400 people.**

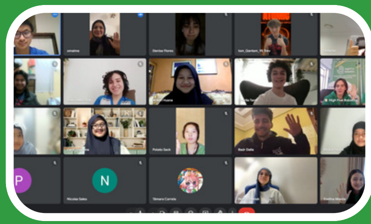


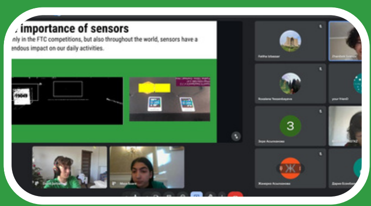
Open Hub
10 teams

Brave around the world



FTC Global Ambassadors
30 people





Redstone Forum
10 people

Volunteers at Robotics Summer Fest
400 people, 8 speakers,
5 artists, 5 FTC teams

Volunteers at STC
26 teams

However, we also have different activities meant to **strengthen our bond as a team**, such as get-togethers, themed parties or team-bulidings.

Treasure Hunt

Halloween Party

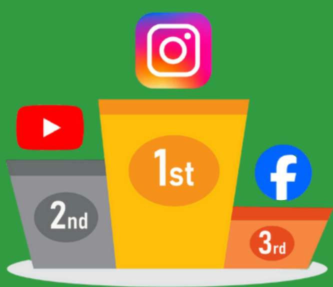
Gaming night

Social Media:

Reach:
- **Instagram**: 260 287
- **YouTube:** 52 000
- **Facebook:** 34 087
- **TikTok:** 23 000

Most viewed post:
- **Instagram**: 6 915
- **YouTube:** 6 967
- **Facebook:** 1 768
- **TikTok:** 3 000

Follower growth:
- **Instagram:** 14.6%
- **YouTube:** 33.6%
- **Facebook:** 11%
- **TikTok:** 17,91%

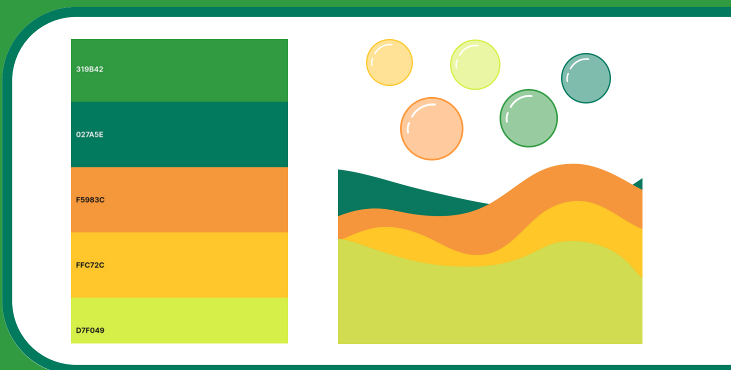


The most viewed video on YouTube is the Robot Reveal published on November 22th 2024, with **over 6.9K views**.

This year, we've also been interviewed by **3 national televisions** and mentioned in numerous articles

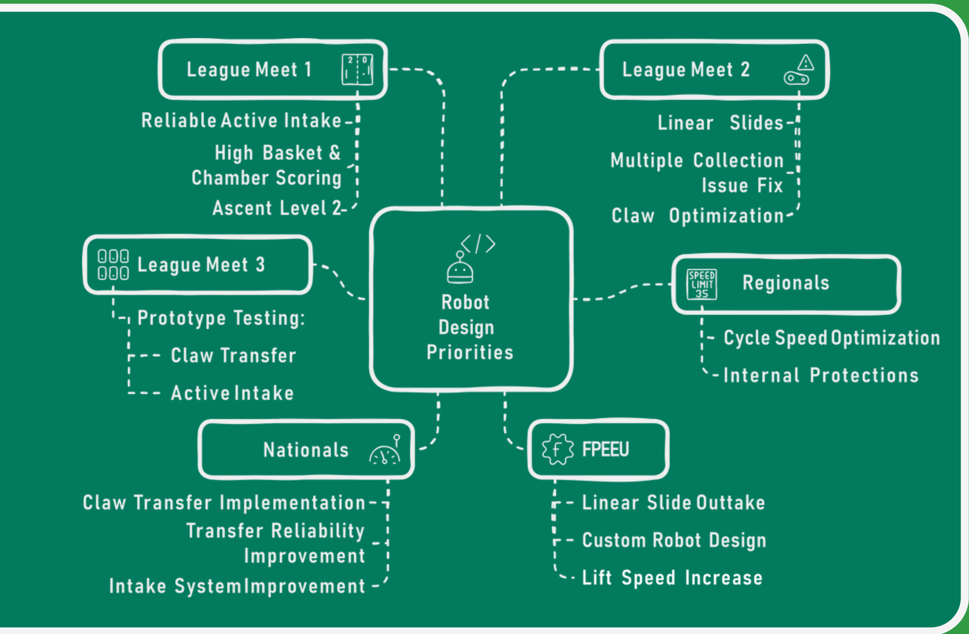
Branding:

Our team is constantly evolving and this year we inspired our visual identity by this season's theme: **waves** and **bubbles**, as well as a **consistent** color palette and design elements. This branding was applied across all promotional and advertising materials (banners, flags, tablecloth).



Season Strategy

THINK AWARD



Design Sessions and Goals

During the **season** we decided to space out our competitions to have enough time to **iterate** thus we had **6 Designing and Prototyping sessions** based on the **feedback** gathered during the matches. As a consequence, we made small **incremental steps** to **mitigate risks taken.** In these **sessions** we set in mind certain **goals** to better focus our **efforts**:

Game Strategy

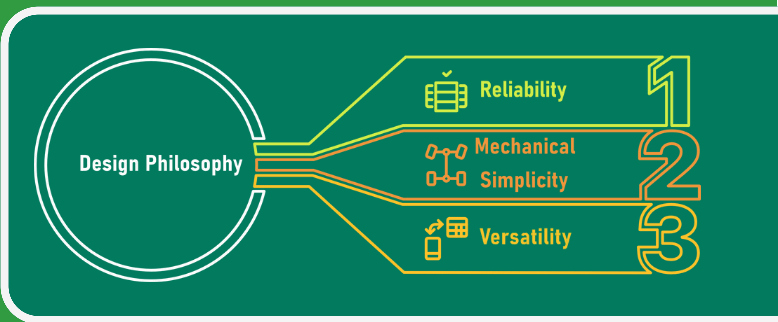
Our game **strategy** initially focused on the **Autonomous period**, which was crucial for ranking. We then implemented **Ascent Level 2** and concluded with **TeleOp**, with our main priority throughout being **Consistency > Speed**.

In **TeleOp**, we determined that **neutral elements** were the most **valuable**, as they are limited and **shared between both alliances**. We set detailed **targets** for each **competition**, aiming for a high **OPR (Offensive Power Rating)**. We also conducted **pre-** and **post-match analyses** of our **objectives** and **achievements**, which **significantly** impacted our **progress**.

National Championship					
	Individual objective	Individual Average Outcome	Individual Score Objective	Individual Average Score	Completion
Auto Samples	6 samples + ascend	3,57 samples High Basket + 0,28 samples Net Zone 3/7 ascend	51	30,42	59,65%
Auto Specimen	5 specimens + park	5 specimens	53	50	94,34%
TeleOp Samples	20 samples	14 samples High Basket + 0,57 samples Net Zone	160	113,14	70,71%
TeleOp Specimen	15 specimens	13 specimens + 0,5 samples	150	139	92,67%
Ascend	Ascend level 2	Ascend level 2	15	15	100,00%

Design Philosophy

Based on our Game and Design Strategy and Process we set the following design principles:



- **Reliability > Speed**
    - Even though this season emphasizes the number of **cycles** achievable, we believe **consistency** is paramount. We need to be able to rely on our robot to operate within normal parameters, **free from risks**.
- **Avoiding Mechanical Complexity**
    - Another **goal** this season was to **develop** our 11 new members and volunteers. To facilitate this, we incorporated many more **standard parts**, making it easier for them to work. Additionally, excessive mechanical complexity reduces reliability.
- **Versatility**
    - While **yellow Samples** are our **primary target**, it's crucial to **adapt** to our alliance partner. Therefore, we've also developed a **Specimen strategy** to account for varying circumstances.

Engineering Design Process:

This process represents a concept through which we can overcome any challenge in an **organized** and **efficient way**, creating an **algorithm**, a precise series of steps to follow after the creation of each new **prototype**.

Engineering Design Process:

THINK AWARD

1.Identify the problem

We start by **identifying** and **analyzing** both **the problem** we aim to solve and the **season's theme**, building a valuable information base for our progress.

2.Brainstorming & Research

Once our objectives are set, we move on to various **brainstorming sessions**. In these, **every member**, regardless of their department, presents both new, **innovative ideas** and concepts implemented by other teams, along with how we could **adapt** them to fit our requirements.

3.Prototyping & 3D design

Once the solution is decided, we start by **implementing** it using standard parts. This gives us **feedback** on the initial parameters, which then allows us to **create** an **optimized** 3D model.

4.Fast Manufacturing

To streamline the **design** and **iteration** process and **avoid wasting** resources and materials, we use 3D printers to create initial **prototypes** of all **custom parts**. Afterward, once we have the final version of parts subjected to **high mechanical stress**, we **communicate** with our **sponsors** and partners at GIC and iPad, companies that assists us with cutting more rigid materials.

5.Testing

For **testing**, we use an **alternative chassis** to evaluate functionality in a system as similar as possible to the competition setup. We check the **reliability** and **speed** of each **iteration**. Subsequently, those that meet our requirements are **tested** at official competitions, such as League Meets.

6.Presenting the solution

Finally, we present our findings to the team to restart the **iteration process**. During this step, we also conduct various **analyses** to **document** the entire process.

07/Sept/2024
Into The Deep Kickoff & KICK/ATHON Quantum Robotics
+ V1 Robot Final

22-31/Sept-Oct/2024
Design and prototyping Robot V2

23/Nov/2024
League Meet 1 - Zilele Robotici #3

15-10/Nov-Dec/2024
Design and prototyping Robot V3

15/Dec/2024
League Meet 2 - Meet-South Quantum Robotics

5/Ian/2025
Prototipare Mecanisme

12/Ian/2025
League Meet 3 - Hide & Meet 2025 Pitești

13-21/Ian/2025
Design and prototyping Robot V3.1

01/Feb/2025
League Meet 4 - Eastern Arena Ploiești

03/Feb/2025
Brainstorming V4 Robot

06-09/Feb/2025
Southern Romania League Tournament

17/Feb/2025
V4 Robot 3D & Prototyping

29/Feb/2025
V4 Robot Final

13-16/Mar/2025
Romanian National Championship

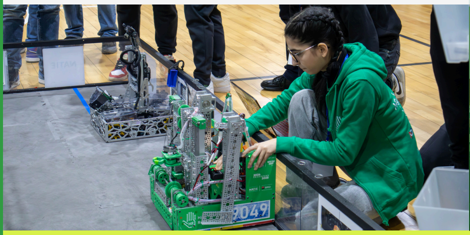
20-24/Mar/2025
Brainstorming V5 Robot

30-23/Mar-Apr/2025
V5 Robot 3D & Prototyping

4/May/2025
V5 Robot Final

1-5/Jul/2025
European Premier Event

Identify the problem | **Research & Brainstorm** | **Build**

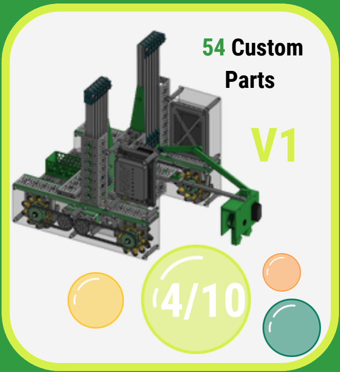


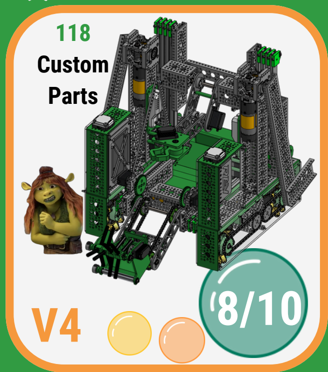
Test | **Present solution** | **Improve**

1	Intake Pasiv	Brainstorming	Prototy	bricatic	ssembl	3D	Fabrication	Assembly	Programare		LM1				
2	Intake Activ	Brainstorming					3D & Prototyping			Brainstorming	3D & Protoryping	Fabrication	Assembly	Programing	
3	Programare	Brainstorming					Calibrating	Trajectory	Auto						
4	Outtake						-			Brainstorming					
5	Săptămână	1 1 2 2 3 3 4 4	5 5	6 6			7 7 8 8 8 8	8 8	8	9 9 10 10	11 11 12 12	13 13	14 14	15	

Robot Evolution

THINK & DESIGN AWARD





Lessons Learned

Stability
Ensuring the robot remains balanced and steady during operation

Collecting and scoring on opposite sides of the robot
Optimizing the robot's speed and efficiency in completing tasks

Intake Reliability
Ensuring the robot's intake system functions reliably and fast

Intake Precision
Enhancing the accuracy of the robot's intake process for better specimen play

Fast and repeatable Actions
Especially for specimen play scoring should be made as effortless and easy as possible to increase speed and reliability

Tension Control
Maintaining consistent tension in the robot's stringing mechanisms

Mechanism Weight
Managing the weight of the robot's components for performance and stability

Material Efficiency
Reducing waste and improving the robot's versatility

Transfer Consistency
The transfer mechanism is a major failure point and needs careful attention during design

Encoder Precision
Utilizing analog encoders for more precise control

V5 - Donkey Overview
108 Custom parts

Lift system with **3 stages** of **MISUMI SAR 230 Slides powered** by **two motors** to **increasse speed** by using a **smaller gear ratios**

Claw transfer and **scoring system** placed on a **double articulated extendo slide arm** to score **samples** and **specimens faster**

Driver Assist System with **two Led indicators**

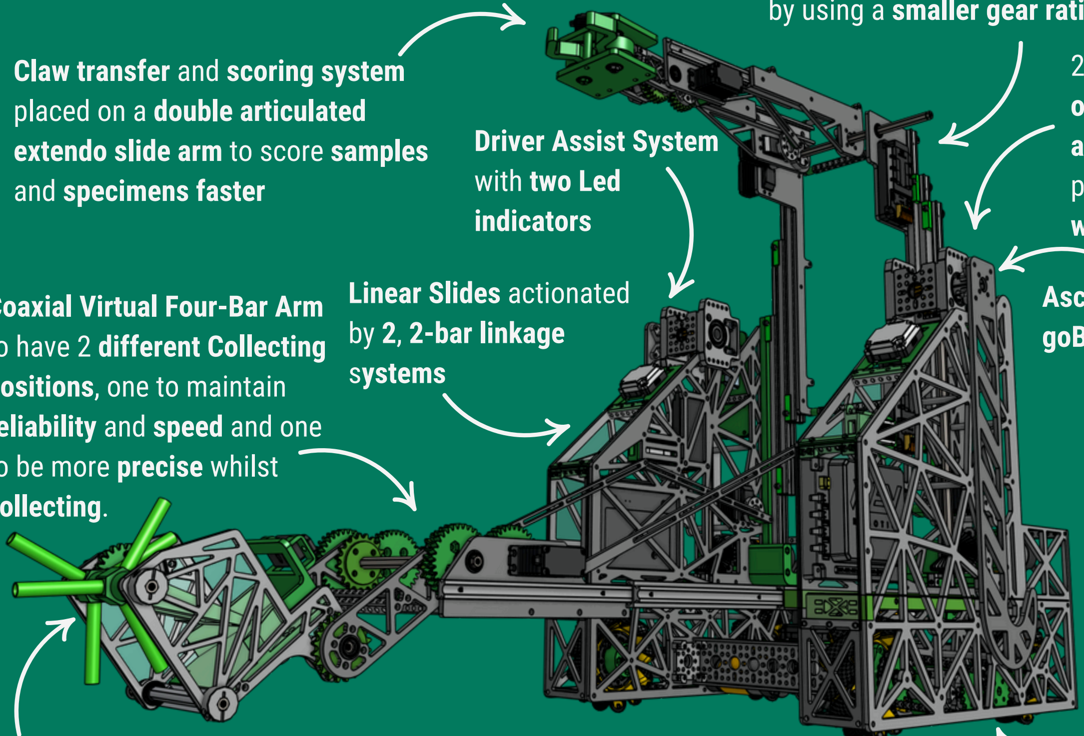
25 topologically **optimized 3mm aluminum** manufactured parts for **strength** and **weight reduction**

Coaxial Virtual Four-Bar Arm to have 2 **different Collecting positions**, one to maintain **reliability** and **speed** and one to be more **precise** whilst **collecting**.

Linear Slides actionated by **2, 2-bar linkage systems**

Ascent Level 2 with **goBILDA Worm Gears**

9/10



Custom 3D printed Pulleys

Servo Actionated **Active Intake** with **1:2 Speed Increse Gear Ratio** and **Bidirectional Tube Placement** to rotate the **Sample**

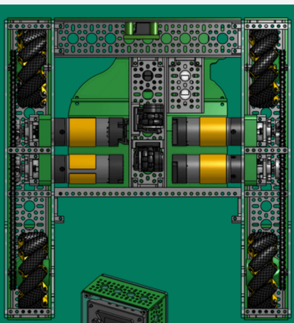
U-Shape Chassis to facilitate **collecting** and **scoring** on different sides of the robot

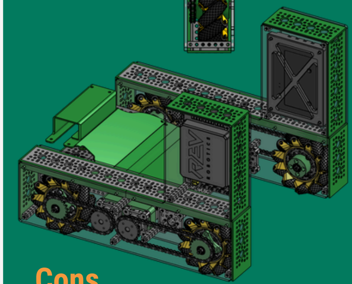
2 **goBILDA 4-Bar Odometry + PinPoint Localization**

Chassis

THINK & DESIGN AWARD

V1





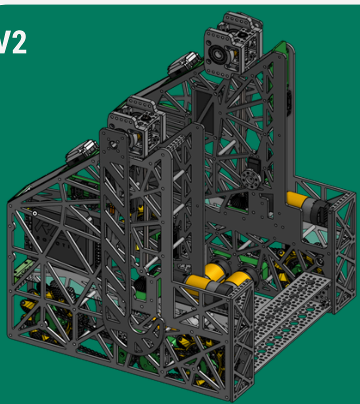
Key Points

- **4-Bar odometry** placed on the robot's inner structure, **simplifying maintenance**.
- **Motors** placed as low as possible to **lower the center of gravity**.
- **Cable protectors** for wheels.
- **Control** and **Expansion Hubs** positioned on the inner plate for **easier maintenance**.
- ***Ventilation*** holes for the **Control Hub** as we use **polycarbonate**, a **thermo-insulating material**.
- As **versatile** as possible to be **used** throughout the **entire season**.
- **U-type Mecanum chassis** for a collection side and a placement side.
- **435 RPM motors** for **higher speed**.
- **Chain** drive.

Cons

- **Higher** than **ideal ground clearance**.
- It wasn't **designed** for the specific needs of the **final design**.

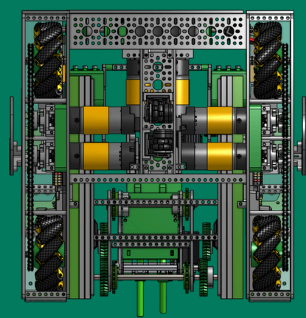
V2



Key Points of Improvement

We were happy with the previous design but we wanted to go **custom** with the **design** because we acquired the **necessary skills** and know how to design it and to **better** suit our **needs**.

- We **integrated** all of the **mechanisms** into the **structure** of the **chassis**.
- We **lowered** the **ground clearance**.
- We created **custom** hand manufactured Polycarbonate **protection plates**.

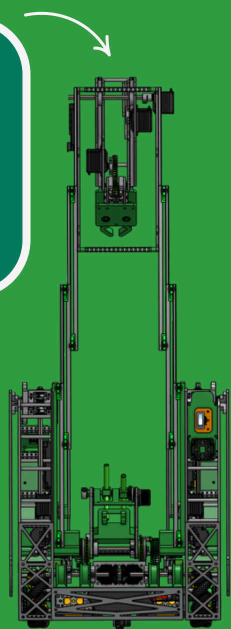


- We **lowered** the **center of mass** by bringing the **battery** and all of the **motors** lower to the ground.
- We **improved** the **cable management** by creating designated paths too wire them.

Lift System

Key Points:

- **3** sets of **MISUMI SAR230 slides**
- **2 goBILDA Yellow Jacket 5.2:1 motor** based on electronic analysis (Math page 13)
- We use a **chain tensioner** to tension the string.
- **Custom** 3D Printed **cable management supports**



Custom pulleys

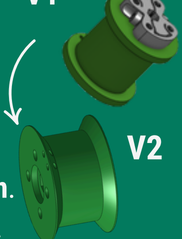
Problem:

Last year, we encountered problems with the **inconsistent** diameter of the string

Solution:

- **Sufficient** width to **prevent** string overlap, ensuring **constant** tension during **extension**.
- Rounded edges to **prevent** string breakage.

V1



V2

Ascend Level 2 mechanism

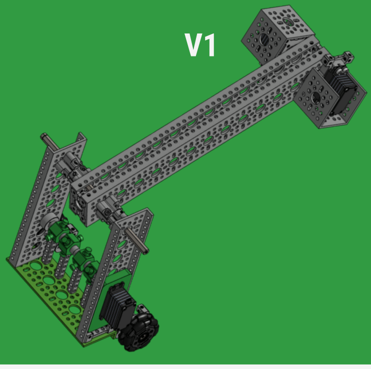
Key Points:

- We use **two goBILDA WormGears** with a **28:1 ratio** and **26.9:1 motors**, resulting in a **final ratio** of **753.2:1**.
- After the program stops, the robot can **remain hanging** for an **extended period**.
- Custom 3mm Aluminum Hooks

Outtake & Transfer System

THINK & DESIGN AWARD

One of our main **goals** this season was to collect with one part of the **robot** and place with another. So, right from the first **League Meet**, we **implemented** a **pivoting arm**.



V1

Key Points:

- Powered by **two servos** to **support** the assembly's weight.
- The entire **Sample intake** assembly was mounted on the **arm**.
- Used the same **arm** for **intake** and **scoring** of **Samples**

Areas for Improvement:

- Had a lot of **unnecessary material**.

V2

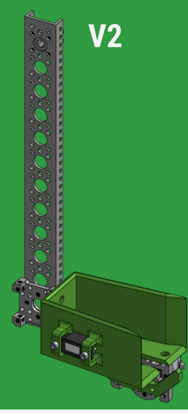
Key Updates:

- Powered by a **single servo** coupled to the **axle** via a **gear train**.
- **Reduced weight**.
- Only the **transfer** assembly was positioned on this **arm**.
- **Increased speed** using **Servo Power Modules**.

Areas for Improvement:

- Due to play (slop) in the **arm's servo** and **linkage**, **transfer** wasn't **reliable**.
- We were still **collecting** and placing **Specimens** with the same part of the **robot**.

V2



V3

V3

Key Updates:

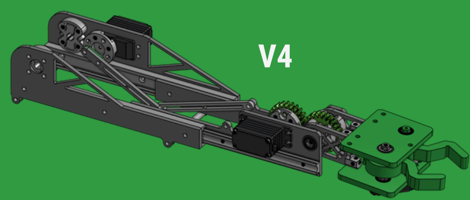
- Moved the **claw** onto the **arm** to be used for both **Specimens** and **transfer**.
- It's **double-articulated** to perform **both tasks**.
- Used our first **metal** parts this year to **increase** the assembly's **rigidity**.

Areas of improvement

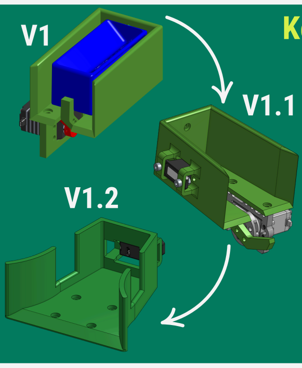
- **Specimen** scoring is made up of a lot of movements.
- Having an extension on it would **help** with both **Specimen** and **Sample** scoring.

V4 Key Updates:

- We added another point of movement in the form of a **linear extension** to help with both **Specimen** and **Sample** scoring.
- We were able to remove a **slide segment** and thus **increase** the **speed** of **scoring.**
- **Implemented a different transfer for specimen play.**



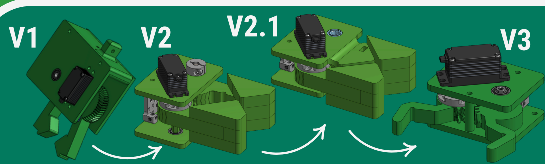
Transfer Bucket



Key Points

- **Color sensor** to **automate** the **transfer** process.
- Initially used with a mechanical stop so it could be tipped over.
- We implemented a **transfer** with a fixed **bucket** as a **backup**, in case we didn't have enough time to **implement** the desired mechanisms.

Claw



Throughout the **season** we tried to improve the functionality and shape of the **claw** by **reducing waste material**. We even tried **implementing** a sensor, but decided against it because it would interfere with the **functionality** of it

Intake System

THINK & DESIGN AWARD

This year, as a **game strategy**, we focused on **neutral** game elements. Therefore, one of our **design** targets was a **fast** and **reliable Active Intake**, sacrificing the **collection precision** of a **claw** for **cycle speed**.

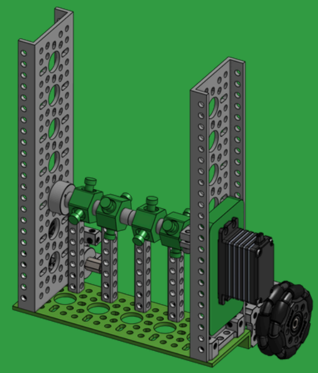
V1

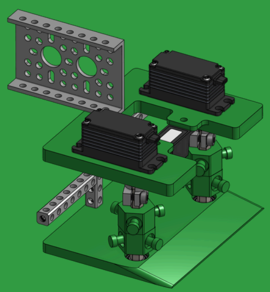
Key Points:

- Vertical tubes.
- **Servo**-actuated (or **servo**-powered).
- Placed on an **arm** to also be used for **scoring.**

Points Of Improvement:

- Can **collect** more than one **element** at a time.
- It's very **large** and **heavy**.
- Would be very difficult to implement for **collecting** from the **Submersible**.
- **Drivers** don't know when they've **collected**.





V2

Key Points

- Horizontal tubes.
- **Reduced** the overall assembly size.
- Implemented a **sensor.**
- Significantly **reduced** the multiple **collection** issue.
- Created a block/stop behind the **intake**, allowing for longer collection tubes and thus **greater reach.**
- Smaller bottom plate.

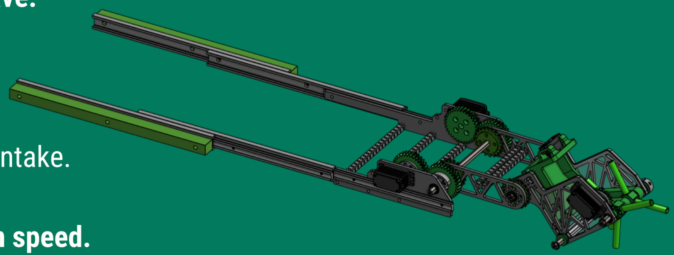
Points Of Improvement:

- The **intake's** design means that if we don't collect a **Sample** instantly, it gets pushed away.
- The **servos** are quite slow for collection.
- The **transfer isn't consistent**.

V3

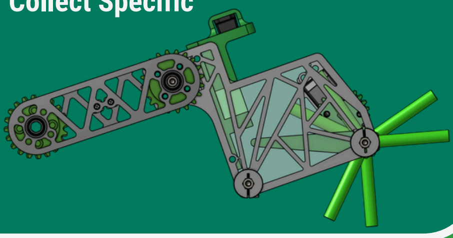
Key Points

- **Mounted on a 4-bar coaxial mechanism, in order to have:**
  - 4 collecting **modes**
  - 2 collecting **positions**
- Used 3mm aluminum plates to **enhance rigidity.**
- Added a **blocker**, preventing samples from exiting the intake.
- Implemented a color sensor.
- Driven by a servo with a **1:2 ratio** to increase **collection speed.**
- Counter-roller driven by a round belt transmission to **improve consistency.**

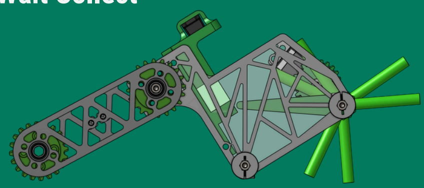


Intake Positions

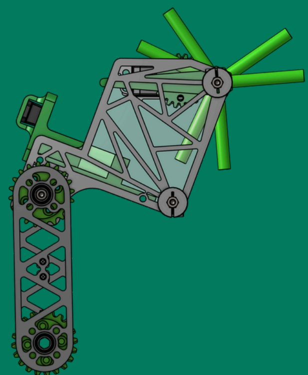
Collect Specific



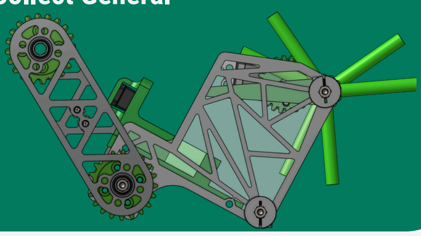
Wait Collect



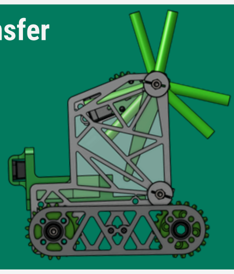
Wait For Specimen Placement



Collect General



Wait Transfer



Physical and mathematical analysis for the subsytems

THINK AWARD

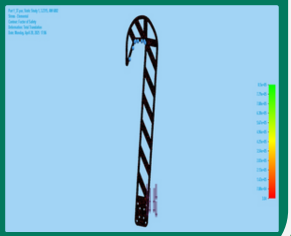
Weight influenced Ascend:

Our **weight** was always **problematic** so we decided to create a dependencies graphic two see how **fast** we could achieve the **Ascend Level 2**.

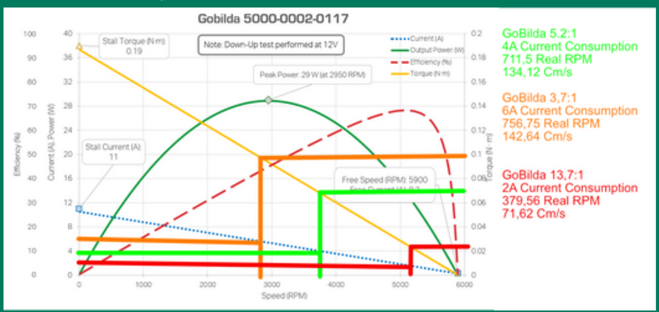
$$\omega_{out} = \frac{223RPM}{28} \approx 7.96RPM \xrightarrow[\text{Velocity}]{\text{Angular}} \omega_{rad/s} = 7.96 \times \frac{2\pi}{60} \approx 0.833rad/s$$
$$v_0 = 0.15 \times 0.833 = 0.125\text{m/s}(\text{Max no load})$$
$$\tau = m \times g \times r = 18 \times 9.81 \times 0.15 = 26.5\ Nm \Longrightarrow t = \frac{d}{v} = \frac{0.47}{0.107} \approx 4.4s \rightarrow\ 18kg$$
$$\tau_{total} = 2 \times 1.4 \times 28 = 78.4\ Nm$$
$$d = \pi \times \frac{0.3}{2} \approx 0.471m$$

Finite Element Analysis of Ascent Hooks:

Knowing that this **component** of our **robot** is under the **most stress** we asked our **sponsors** and **partners** at **iPad** to help us **analyze** this **component** under our **stress conditions**. We **concluded** that our **design** was **more** than **capable** to handle **double** the **forces** it was under in both **stress** and **translation** which we determined to be more than **sufficient** of an **error margin**.



Electronic analysis of the motor on the vertical extension:



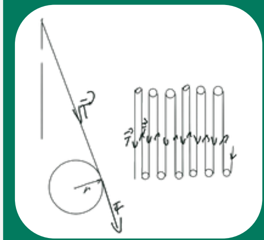
Problem:

After changing the **lift motor** for **League Meet 4**, we started noticing quite a few problems with battery consumption, so from than on we have placed great importance on choosing the right motor with the help of electrical analysis.

Solution:

Back than we realised that the **motor** that best fit our needs was a **goBILDA YellowJacket 5.2:1** and by keeping the same motor we are losing **4A** of power consumption and only lose **40RPM** which we decided was an advantageous **Trade-Off.**

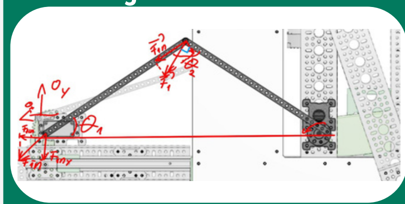
The torque of the pulleys for the extension:



To gain a better understanding of the system and to perform the electronic analysis of the **motors**, we calculated the mechanical **torque** of the pulleys resulting from the weight of the assembly.

$$\tau = m \times g \times SpoolRadius \times \times GearRatio = 2kg \times \frac{9.81N}{kg} \times 0.018m \times \frac{1}{2} = 0{,}175Nm$$

Analysis of the minimum/maximum force exerted by the linkage servo:



Problem:

Once we implemented the actuated **horizontal extension system** we encountered many problems with the mechanism's inertia, so we examined the system.

Solution:

We decided to add another **servo** to double the effective force. We also **observed** that in the retracted position, used for **transfer**, the **servo** encounters the least resistance — yet it is the most important position when it comes to extension positioning **accuracy**.

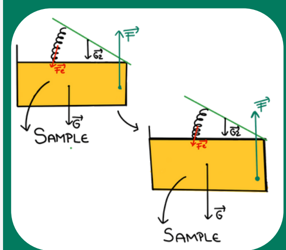
Initial Force:

$$F_{fy} = \frac{\tau}{l} \times \cos(|90° - \theta|) \times cos\theta_2 =>$$
$$F_{Min} = 3{,}61N \quad F_{Max} = 9{,}44N$$

Momentary Force:

$$F_{Min2} = 2 \times F_{Min} = 7{,}22N \quad F_{Max2} = 2 \times\ F_{Max} = 18{,}88N$$

The force required to transfer the Sample from the Intake to the Outtake:



While thinking about the transfer process we realised that in order for the Sample to remain in the Intake after we collected it we had to install a 3D printed piece with some springs.

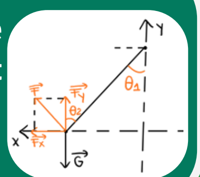
Furthermore we caluclated the necessary force to extract the Sample.

$$F_{\text{pull}} = G_{\text{sample}} + F_{\text{stopper,Y}} + F_{\text{tubing,Y}}$$
$$G_{\text{sample}} = m_{\text{sample}} \times g = 0.0395 \times 9.81 \approx 0.388\,\text{N}$$
$$F_{E1} = 0{,}2N, F_{E2} = 0{,}2N, F_{E3} = 0{,}7N, F_{tubing} = 1{,}12N$$
$$F_{\text{stopper,Y}} = F_{\text{stopper,N}} \times \cos(\alpha) = 0.143cos^2(\alpha) + 0.905cos(\alpha)$$
$$F_{\text{pull}}(\alpha) = 0.388 + 0.143\cos^2(\alpha) + 0.905\cos(\alpha) + 1.12$$
$$F_{\text{pull}}(60^\circ) = 1.997\,\text{N}$$

Arm:

To ensure we have enough force to place the **Specimens**, we calculated the **impact** of gravitational force on the system.

$$\tau = F \times l, \tau_{arm} = 0.41Nm, \tau_{wrist} = 0.5Nm$$

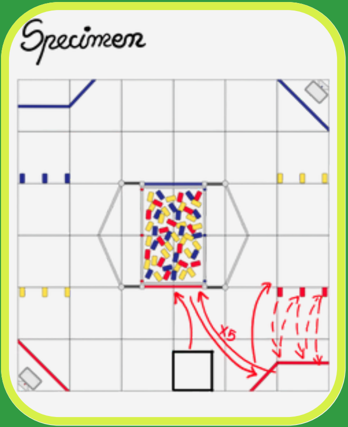


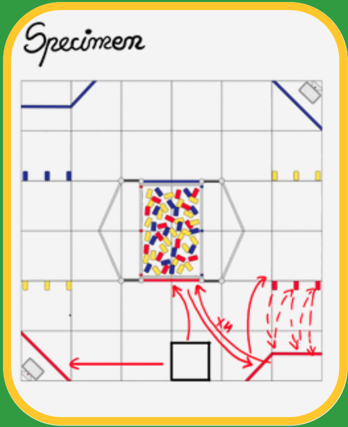
Auto & TeleOp:

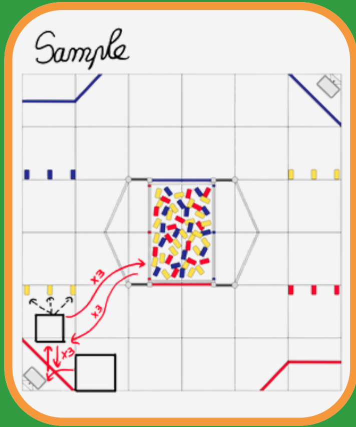
CONTROL AWARD

We developed **2 different Specimen Autos** and one **Auto** for **Samples** only. When we play **Specimens** we have 2 options to choose from, based on both our **Alliance** and the randomization, a **6+0 Auto** and a **5+1** one.

Regarding our **Sample Auto** we created a **0+6** one. At the end of the **Auto** period we **park** in all of the cases mentioned above, both in the **Observation Zone** and scoring a **Level 1 Ascend**. We also divided the Submersible in **9 zones**, for a much precise collection.

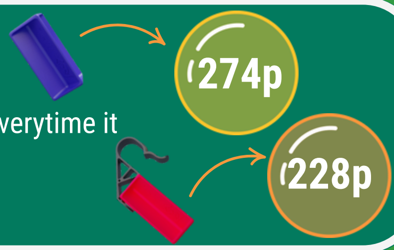




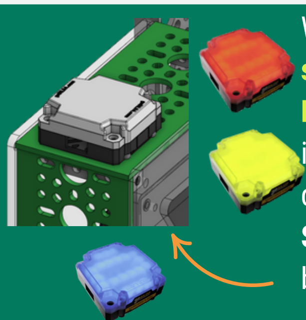


TeleOp Enhancements:

- **Automatic** ejection.
- **Leds** show the collected **Sample** colour.
- **Sliders** retract after the **Intake collected.**
- **Chassis speed** decreases while specific **collecting** for better **precision.**
- **Field Centric** usage.
- Resetting the **Lift** position everytime it goes to the neutral pose.



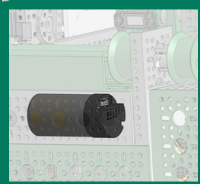
Sensors & Localizers:



We use an **innovative Driver Assist system with goBILDA Indicator Lights**, color-coded to provide information to the Drivers. The **LEDs** display the color of the collected **Sample**, giving them **visibility** even in blind spots.

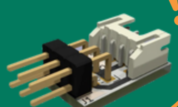
We use a **Rev Color Sensor V3** in the **active Intake** to determine the color of the collected **Sample**. This is the core component of most of our **automations**.

We use the **motor encoder from the Lift** to operate an **automation** based on the current it draws.



We use **goBILDA 4-bar Odometry** to minimize **oscilation** on the pivot axis as much as possible. Additionally, we also use **PinPoint Odometry Calculator** which **solved** most of **our problems** regarding the chassis angle.

We use multiple **analog inputs** for measuring voltages from our Linkage, Outtake Arm, Intake Arm and Intake Wrist. This helps by giving near real time insights about the position of the servo.



Loop Time Optimizations

Bulk Reading:

We made it a prominent **goal** of ours only to have to bulk read one of our hubs, the **Control Hub**, as bulk reading both hubs is redundant and adds a lot of delay between loops.

Power Cache:

We **cache** our **motor** & **servo** powers to ensure that we don't end up:

A: Stalling our motors

B: Pulling extra voltage and sending extra reads/writes

PinPoint Computer

Problem:

1. **ESD** (electrostatic discharge).
2. Since we use **Servo Hubs**, **PinPoint** shared power with other electrical components such as RS485 cables, sometimes **losing power.**

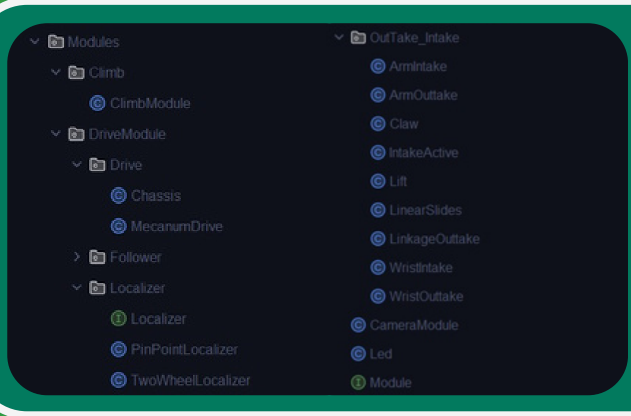
Solution:

1. We isolated it in **aluminum foil tape** and we placed it on a 3D printed plate. We also added **plastic screws**.
2. We moved the **PinPoint** on our **Expansion Hub**

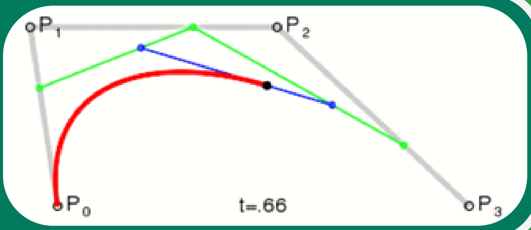
Software Architecture

CONTROL AWARD

For our programming structure we decided to use **subsystems,** which work as a **Finite State Machine** and a main robot **class** which includes all of the other robot components, making our **software** more **modular**. Additionally, this makes **debugging** a lot **easier**, since it allows each **subsystem** to work **independently**. This way, if one **component** of the robot **breaks**, the **rest** will still be **functional**. All of the subsystems classes come with specific, **premade actions** which are very accessible when coding our **Auto**.



Navigation Algorithm Speedi



Speedi is our navigation algorithm that enables the creation of complex trajectories using **Cubic Bézier Curves** or **lines**. It consists of five main components:

- Locator
- Trajectory creator
- Motor power calculation
- Motor power distribution
- Calibration programs

Localizer:

We opted for goBILDA 4-Bar Odometry Pods since we wanted to use odometry combined with **Pose Exponentials** which we calculated through the **Control Hub** with the help of the formula on the right. Furthermore we added a **PinPoint Odometry Calculator** for **better precision**.

$$G\begin{bmatrix}\Delta x\\ \Delta y\\ \Delta\theta\end{bmatrix}=\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\frac{\sin\omega t}{\omega} & \frac{\cos\omega t-1}{\omega} & 0\\ \frac{1-\cos\omega t}{\omega} & \frac{\sin\omega t}{\omega} & 0\\ 0 & 0 & t\end{bmatrix}R\begin{bmatrix}V_x\\ V_y\\ \omega\end{bmatrix}$$

Trajectory Creator:

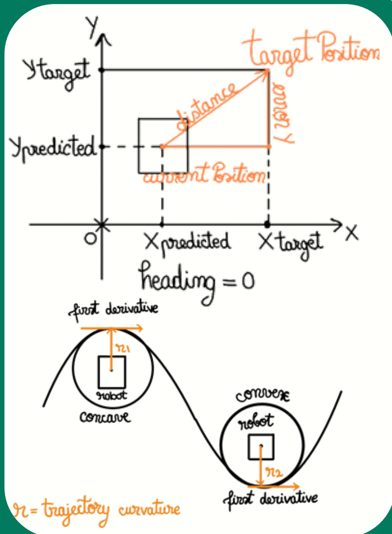
We used two types of trajectories:

1. **Lines** – For this type of trajectory, the robot receives a set of 3 values, which we call a Pose: an x, a y, and a heading. The robot then calculates the **fastest path** between these two points.
2. **Cubic Bézier Curves** – A **Bézier curve** is defined by a set of control points P0 to Pn, where n is the order of the curve. The first and last control points are always the endpoints of the curve; however, the intermediate control points generally do not lie on the curve.

Motor power calculation and distribution:

To calculate the motor power, which must be provided in the form of a vector depending on the trajectory, we used two different methods:

1. **GoToPoint** – This system operates through **TargetPositions**, which are positions (Poses) directly provided by the programmer during the autonomous period. The robot follows a linear trajectory to reach them. After receiving a new target, the robot uses **two PID controllers** for heading and **two Squids** for translational movement.
2. **SplineFollower** – This algorithm performs four calculations for correction or progression along the trajectory, in the following order of importance:
   - **Correction of position** on the trajectory using two **translational Squids**
   - **Correction of centrifugal force**
   - **Heading correction** using a **PID** controller
   - Continuation along the trajectory only occurs when the magnitudes of the other vectors are small enough; this is represented as a length.



$$correctionVector = Vector.polar(CentripetalScalingFactor * TotalMassOfRobot* Math.pow(trajectory.firstDerivative(currentT).scaleToMagnitude(1).getMagnitude(), 2) * curvature), trajectory.firstDerivative(currentT).getRelativeHeading() + Math.PI/2* Math.signum(trajectory.secondDerivative(currentT).getRelativeHeading()))$$