

25865



FeNiX.EXE

IGNITE THE PASSION

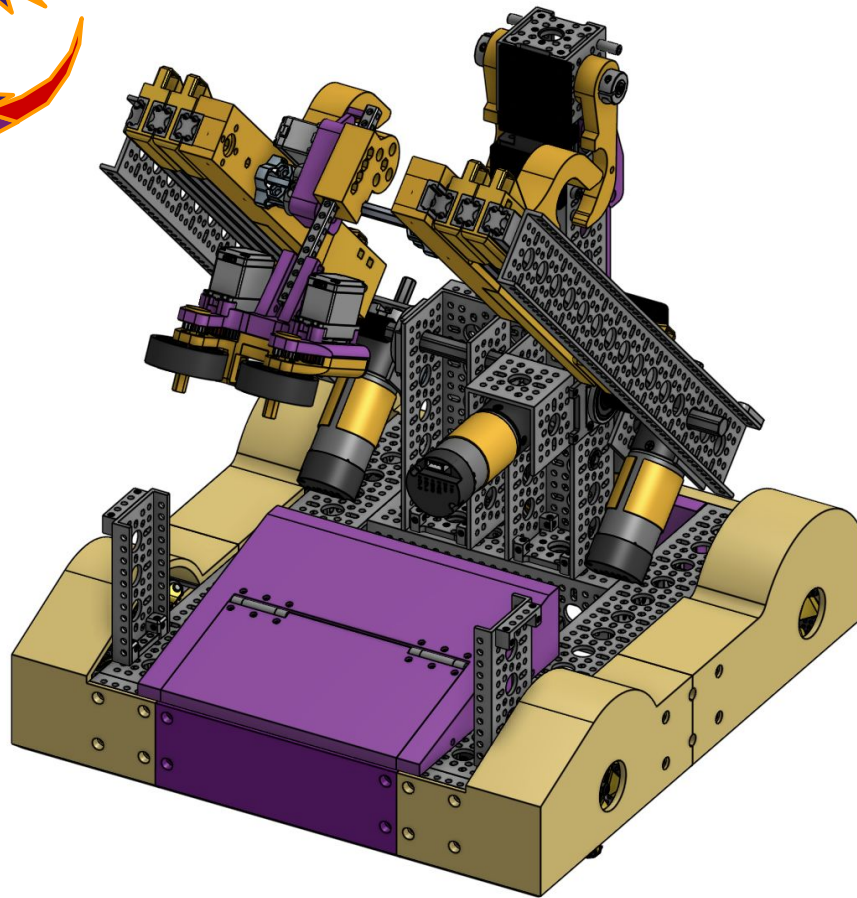


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WE ARE FENIX.EXE 25865

OUR STORY

We are driven high schoolers who came together, in the summer of 2024, from diverse FLL and FTC backgrounds. We all wanted to be well versed in the various aspects of the engineering design process of building an FTC robot. We learned through building a summer robot, lessons from our coaches and mentors, industry visits, and online courses. This experience, as well as our commitment to give back to the community inspired us to form our team, FeNiX.exe. We now are focused on building the best possible robot for the "Into the Deep" challenge, as well as igniting the passion for STEM in our community.

OUR GOALS

1: Learn & Grow Our Skills

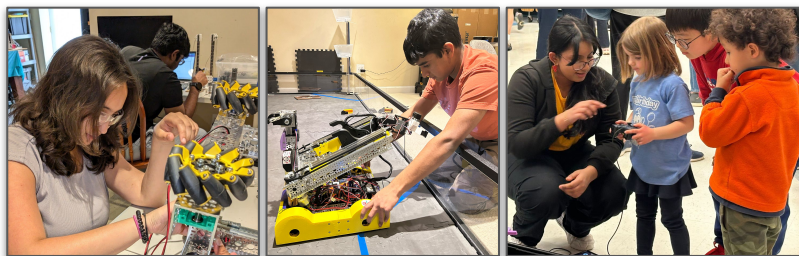
Improve our technical and soft skills such that **every member can CAD, code and lead their own outreach.**

2: Build the Best Robot Possible


Work closely with mentors and coaches to rapidly **iterate** through various ideas and designs, while applying **scientific methods** to identify the **best solutions.**

3: Ignite the Passion for STEM


Organize **purposeful** outreach to engage with our community and **inspire younger and underrepresented students around the world.**



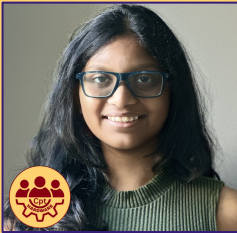
Ram




3rd Year in FTC
Elbow & Slides




Aadya





2nd Year in FTC
Intake Business




Tushaar



3rd Year in FTC
Hang System

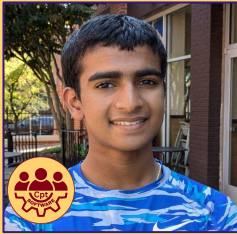
Deven





2nd Year in FTC
Drivetrain Tele-Op




Nikhil



2nd Year in FTC
Autonomous

Daniel



4th Year in FTC
Unit Testing



Annika



1st Year in FTC
Portfolio Business




Samsritha



2nd Year in FTC
Marketing Wiring




Focus

-  Leads
-  Hardware
-  Software
-  Marketing
-  Business

TECHNICAL SKILL DEVELOPMENT

CAD: Experienced teammates and coaches used the OnShape curriculum to teach CAD to junior teammates. **Now, everyone contributes to our CAD designs.**

Coding: Software teammates and mentors taught configuration and blocks. **Now, everyone writes testing code for our hardware prototypes.**

Physics: Coaches and mentors taught us **torque calculations, beam deflection,** as well as electric **power distribution** to prevent brownouts. **Now, our designs are more reliable and effective.**

Advanced Java: Software team learned finite state machines, design patterns, and modular coding. **Now, our code supports drivers through preset positions.**



PLANNING & ORGANIZATION

ORGANIZING WITH A KANBAN BOARD

KANBAN V2

KANBAN V1

Coach's Wall + Post-it

Task Tracking

► V0: Disorganized tracking was inefficient

KANBAN

- V1: **Post-it** KanBan streamlined us
- V2: **Trello** KanBan accelerated us

**NO MULTITASKING
NO REDUNDANCY
CLEAR PLANS**

RISK MANAGEMENT

Hardware Risks	Mitigation
Servos kept breaking on intake	Learned to fix servos & added hard stops
Sensors frying ports in control hub due to static	Added ferrite chokes & anti-static spray before every run
Software Risks	Mitigation
Variability in hardware systems	Easy to modify code when hardware is changed
Impact of debug telemetry on the speed of loop cycles	Removed all multi telemetry, switched to bulk reads, & created a program to track the loop cycle
Incomplete tele-op testing and optimization	Dedicated testing drivers whose job was to point out flaws and inefficiencies

FINANCES & FUNDRAISING

Raised \$2,480 for feminine hygiene products for 75 girls that live on Comoros Islands, off the east coast of Africa



Expenses	Budget
Electronics	\$1,795
Mechanical	\$1,600
Event Registration	\$745
FTC Field	\$695
Pit Expenses & Spirit	\$600
Additional Supplies	\$1,000
Facilities	\$500
Tools	\$500
Outreach Initiatives	\$3,000
Total	\$10,435.00

SUSTAINABILITY

The budget covers summer 2024 and main season.

- \$2,500 from **Google**
- \$2000 from **MSBR**
- \$1600 from **leidos**
- Tool donations from **Stanley Black & Decker**
- Discounted apparel from



leidos



Google

OUTREACH WITH A PURPOSE

INTERNATIONAL IMPACT



Created **675** reusable hygiene products for **225** girls in Comoros, Botswana, Uganda, & Haiti

3D printed female reproductive health models

SUPPORTING FIRST



Mentoring FLL Teams:



- #53146 - Lucky LEGOs
- #68934 - Running Beagles
- #63411 - Sonic Zotecx

Hosted an FLL Explorer Festival



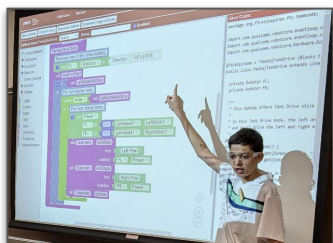
Mentoring FGC (FIRST Global Challenge)



#TeamComoros



- ▶ **Assisting 12+** FTC teams
- ▶ **44 hours** of volunteering at FIRST events
- ▶ **Taught 2 workshops** for FTC rookies at kick-off



40+ Events

1400+ Students Engaged

550+ Hours

50% Female Participation

\$4800+ Raised

26% Minorities

EMPOWERING GIRLS

- 30+ girls:** robotics badge training
- 75+ girls:** introduced circuits & FTC

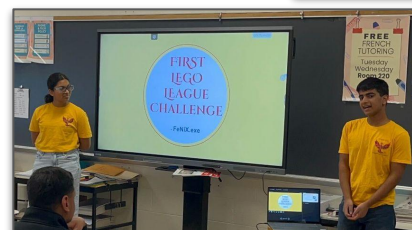


INTRODUCING FIRST

- ▶ Introduced **45+ patients & their families to robotics** at the American Partnership for Eosinophilic Disorders Conf.
- ▶ Taught **10+ kids FLL** at Cabin John MS.
- ▶ **5 STEM Nights**
- FLL Info session at **March Madness**



Rockville Robotics



ADVOCATING FOR STEM

- ▶ **Lobbied to US Senators** and their aides to increase STEM Education funding at the National Advocacy Conference.
- ▶ Introduce the **Mayor of Rockville** to FIRST at National Night Out.



ENGAGING WITH THE STEM COMMUNITY

COACHES & MENTORS

Head Coach: Dr. Pankaj Oberoi

Meso Scale Diagnostics

Asst. Coach: Dr. Olga Ratsimor

Department of Defense (DoD)

Outreach Coach: Ruchi Pande

ES Search Consultants

5 Hardware Mentors:

Ishaan Oberoi - SpaceX

Arjun Oberoi - Student at Stanford

Bernie Jin - Student at MIT

Dr. Brent Laird - DoD

John van Eopal - NASA

4 Software Mentors:

Dr. Balaji K. - Cambium Inc

Mallik Rao - Leidos

Dr. Scherer - George Mason U.

Solomon Ucko - Student at UMD

2 Outreach Mentors:

Jyoti Mehta - USPTO

Kelly Ann - Facebook Group



HOW WE ACQUIRED MENTORS

- ▶ Leveraged family & friends to **connect with industry experts**
- ▶ **Introduced** local professionals, local and federal officials to **FIRST**
- ▶ Our mentors **refer** us to other experts & professionals

6 VISITS

NIST National Institute of Standards & Technology

US Patent & Trademark Office

Institute of Electrical & Electronics Engineers

Naval Research Lab

NASA National Aeronautics Space Administration

Rotary International

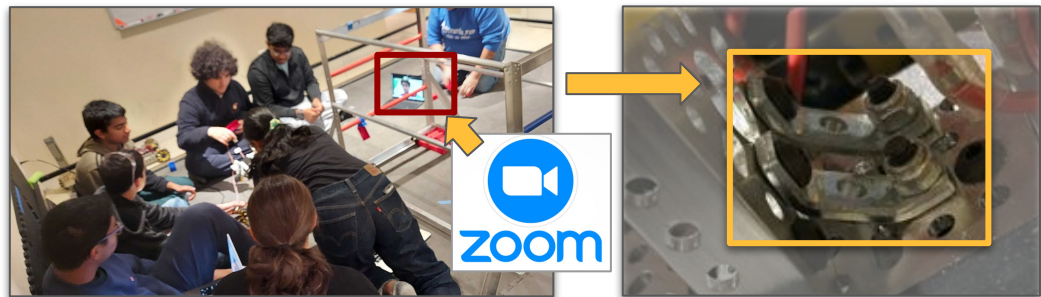


HOW WE LEARN FROM OUR MENTORS

4 Design & 2 Software Reviews



Outreach Mentor, Jyoti Mehta **connected us with IMARA Comoros** & helped us design hygiene products. Additionally, Mentor Kelly-Ann **recommended fabrics** and provided feedback on our designs



Hardware Mentor, Ishaan Oberoi, taught us about impact of **beam deflection** on our elbow. We installed **angle brackets** to minimize **U-Channel flex** in our V1 robot, and changed the orientation of our U-Channels in V2 to **completely eliminate deflection**.

Software Mentor, Dr. Balaji, taught us:

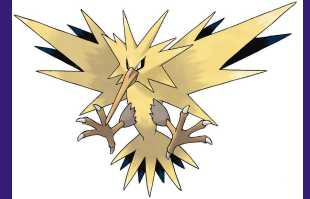
- ▶ **Code structuring,**
 - ▶ **Layered design** with focus on **configurability & testability,**
 - ▶ Effective use of **object oriented concepts** (i.e. **inheritance & interfaces**).
- Additionally, he facilitated **2 code reviews** with the software team



MEET OUR ROBOT:

ZAPDOS

Electric Pokémon



2 Set Custom Misumi Belted Slides

3 stage SAR330,
durable & lightweight
powered by two 1150
rpm motors (page 11)

Ascent 2 Hooks (page 10)

Linear Actuator & Pop-out Hooks for Ascent 2 (page 10)

Worm Gear
reduces backlash
on the elbow
(page 9)

Wrist
pitch movements
(page 12)

Wheel Guards
prevent samples
from getting caught
in the drive train
(page 9)

**Automated Active
Custom Intake**
uses color sensor to
detect and intake
samples &
specimens (page 12)

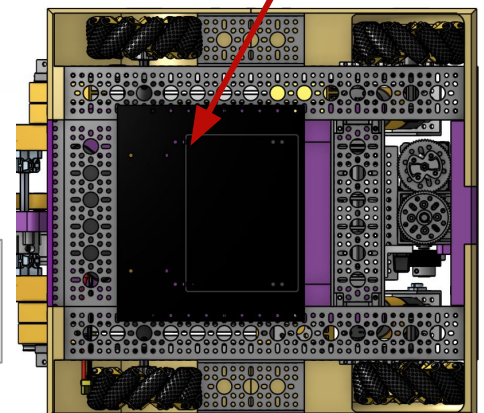
O-Drivetrain & Custom Base Plate

low center of
mass & housing
for electronics
(page 9)

Elbow Hard Stops
eliminate play when
intaking both samples
and specimens
(page 9)

**2 Odometry Pods
& Pinpoint Odometry Computer**
quick & accurate localizations (page 14)

Autonomous: 5 specimens & park or 4 sample & park (page 14)
TeleOp: Finite State Machine (FSM), modular & layered design (page 15)



GAME STRATEGY

Our mentor Ishaan helped us design scoring matrices to compare tasks & their point output

AUTONOMOUS

	Points	Scoring Opportunities	Max Score	Realistic(Higher is Better)	Realistic Scoring	Difficulty (5 easy, 1 difficult)	Overall Value
NET ZONE	2	60	120	4	8	3	24
LOW BASKET	4	15	60	3	12	3	36
HIGH BASKET	8	15	120	3	24	2	48
LOW CHAMBER	6	20	120	2	12	2	24
HIGH CHAMBER	10	20	200	2	20	2	40
ASCENT 1	15	1	15	1	15	5	75

TELE-OP

	Points	Scoring Opportunities	Max Score	Realistic	Realistic Scoring	Difficulty (5 easy, 1 difficult)	Overall Value
NET ZONE	2	60	120	15	30	4	120
LOW BASKET	4	60	240	12	48	3	144
HIGH BASKET	8	60	480	12	96	2	192
LOW CHAMBER	6	20	120	10	60	3	180
HIGH CHAMBER	10	20	200	15	150	2	300
ASCENT 1	3	1	3	1	3	5	15
ASCENT 2	15	1	15	1	15	3	45
ASCENT 3	30	1	30	1	30	2	60
PARKING	3	1	3	1	3	5	15

STRATEGY FOR VI ROBOT

Strategy 1: 4 Samples into High Basket

- ▶ 1 Sample pre-loaded
- ▶ 3 Samples into High Basket
- ▶ Ascent 1

4 x



Strategy 2: Deposit 6 Samples into High Basket

- ▶ Deposit any remaining samples not in submersible
- ▶ Cycle from submersible to baskets
- ▶ Ascent 2

6 x



STRATEGY FOR CHESAPEAKE CHAMPS WITH V2 ROBOT

AUTONOMOUS

Strategy 1: 5 Specimens on High Chamber

- ▶ 1 Specimen preload; 1 with human player
- ▶ 3 Samples pushed into observation zone then clipped on high chamber

4 x



Strategy 2: 4 Samples into High Basket

- ▶ 1 Sample preload
- ▶ 3 Samples into High Basket
- ▶ Ascent 1

5 x



TELE-OP

Strategy 1: 9 Samples into High Basket

- ▶ Deposit any remaining samples not in submersible
- ▶ Cycle from submersible to baskets
- ▶ Ascent 3

9 x



Strategy 2: 6 Specimens on High Chamber

- ▶ Cycle from submersible to high chamber through the human player
- ▶ Ascent 3

6 x



STRATEGY FOR WORLDS CHAMPS WITH V3 ROBOT

AUTONOMOUS

Strategy 1: 4 Samples into High Basket

- ▶ 1 Sample preload
- ▶ 3 Samples into High Basket
- ▶ Ascent 1

4 x



Strategy 2: 5 Specimens on High Chamber

- ▶ 1 Specimen preload; 1 with human player
- ▶ 3 Samples pushed into observation zone then clipped on high chamber
- ▶ Ascent 1

5 x



TELE-OP

Strategy 1: 13 Samples into High Basket

- ▶ Deposit any remaining samples not in submersible
- ▶ Cycle from submersible to baskets
- ▶ Ascent 2

13 x



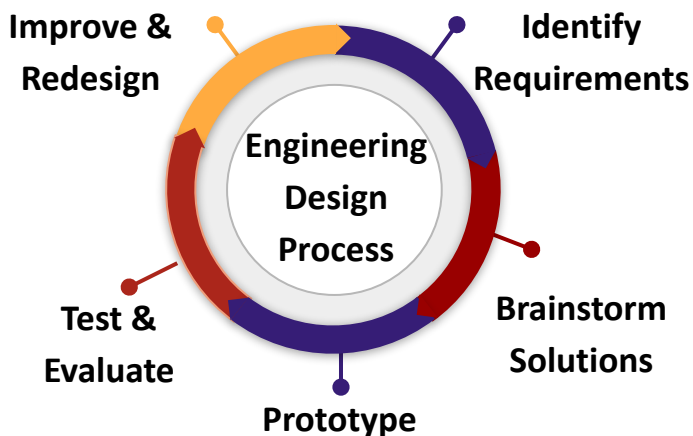
Strategy 2: 8 Specimens on High Chamber

- ▶ Cycle from submersible to high chamber through the human player
- ▶ Ascent 2

10 x



HARDWARE DESIGN PROCESS



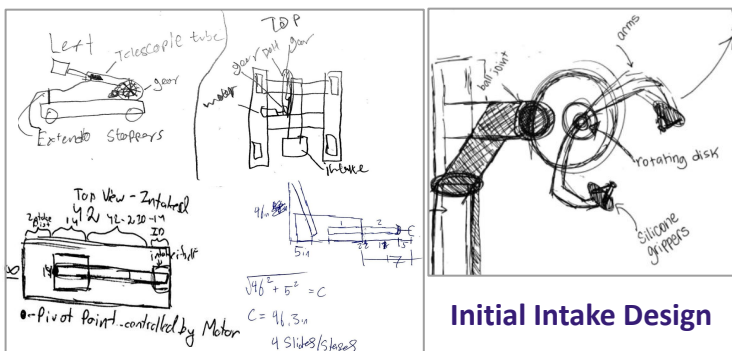
IDENTIFY REQUIREMENTS

Creating strategy matrices helped define & prioritize our robot requirements:

- ▶ Extend to the tall bucket and high chamber
- ▶ Pick up samples from the submersible regardless of the orientation
- ▶ Modular design for subsystem
- ▶ Fast lightweight robot with quick cycle times
- ▶ Scoring in multiple ways to maximize alliance scores

BRAINSTORMING

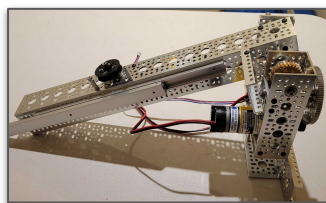
Brainstormed various hardware ideas & created initial CADs & sketches:



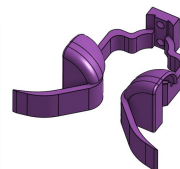
Initial Intake Design

PROTOTYPING

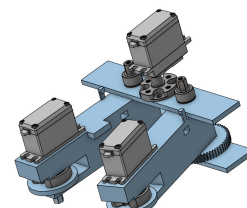
- ▶ Initial prototypes of hardware built using off-the-shelf parts & laser cut wood
- ▶ Iterated over prototypes and switched to CAD & custom parts as the design became more final



Initial Elbow Prototype



Passive Claw Prototype CAD

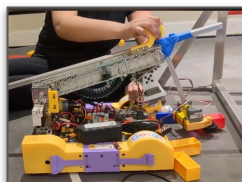


Active Intake Prototype CAD

TESTING & EVALUATION

Agile Methodology:

- ▶ Frequently tested & rapid iteration
- ▶ Tracked issues in our issues log
- ▶ Prioritized issues for fixes



subsystem	failure	# of failures
intake	loose standoff	1
other	both ps4 controller 1 and 2 with hub 3 disconnected when robot hit submersible	1
other	ps4 controller 1 had lag when driving around	1
software	intake button cycle not working when robot at low battery	1
other	Ping spikes with driver hub to control hub connection	1
intake	servo connection between the servo wire and the telephone wire broke(all 3 broke)	3
intake	pitch servo has bounce - does not stay in the same position	1
intake	broken claw servo	1

IMPROVING & REDESIGN

Addressed design weaknesses that showed up during testing & driver practices with interim fixes (i.e. tape/zip ties) while were re-printed parts with proper fixes.




Quick & temporary fix during testing



LESSONS LEARNED

- ▶ **Frequent design iterations & testing** of hardware and software subsystems is the **best way to find optimal solutions**.
- ▶ **Modular hardware & layered software design** allows to **swap out & upgrade** sub-systems.
- ▶ **Kanban task tracking & daily slack updates** boosted our collaboration & iteration speed.

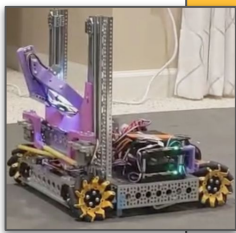
- ▶ Coaches & Mentors helped us think through design options. 
- ▶ Maintaining an up to date CAD helps make sure that build stays on track without waiting on parts.
- ▶ **Team Work is key** & each task has one owner.

TIMELINE & SCHEDULE

June

First prototype of our summer robot

Experimenting with sensor responses on test robots



July

Building final summer robot with drive practice

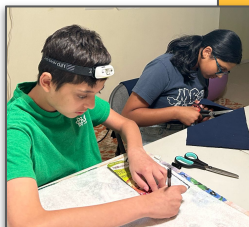
Building tele-op in blocks



Aug

Each team member designed their own subsystem

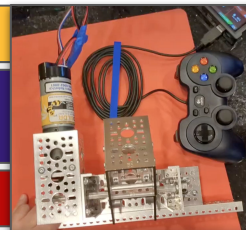
Learning Java & Blocks



Sep

Initial prototypes & design for V1

Learning Road Runner



Oct

Building V1 of our robot & designing V2

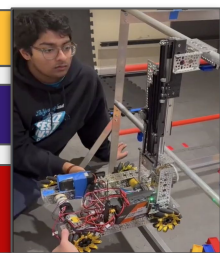
Developing autonomous paths & writing tele-op functions



Nov

Building V2 & driver practice

Integrating code with the final robot & finalizing auto paths



Dec

Brainstorming V3 Design

Re-work code architecture & create unit testing code



Jan

Construct and Drive Test V3

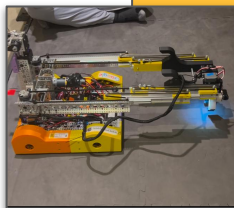
Code integration & auto paths



Feb

Driver practice for Chesapeake Championship

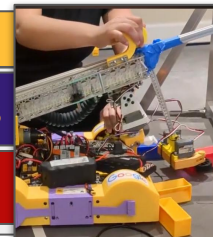
Finalizing auto & tele-op



Mar

Redesigning intake for Worlds

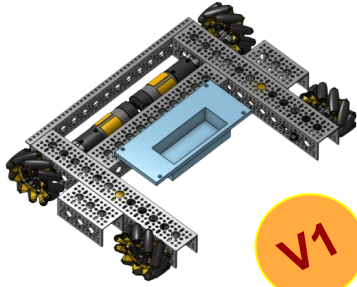
Optimizing software



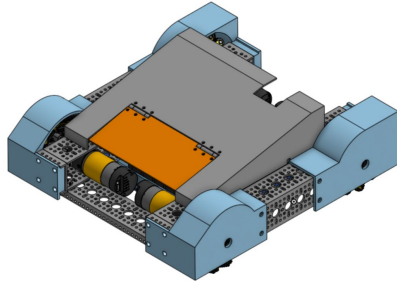
DRIVETRAIN

GOALS

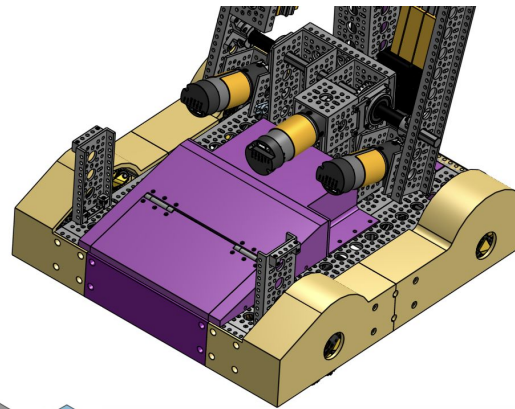
- ▶ **Lightweight** 14.5" x 15" drivetrain (more extension into submersible)
- ▶ Can **strafe** to adjust pickup positioning
- ▶ **Low center of mass**
- ▶ **Easy to add subsystems**



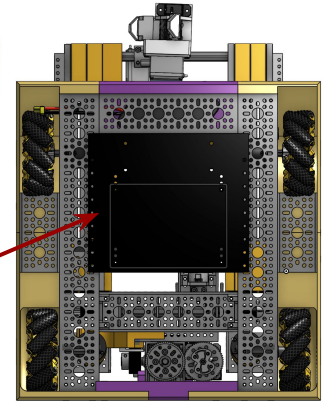
V1



VERSION 2



V2



Custom Plate

DRIVETRAIN: VERSION 1

- ▶ **A-drive** - space in the front accommodated initialization of intake and slides.
- ▶ **2 of the 4 motors directly drive our wheels** to gain more space for other motors.
- ▶ **312 rpm motors** (vs 435 rpm) for more torque.
- ▶ **Dead wheel odometry** to enable autonomous.

V1 Problem: Limited space for electronics

DRIVETRAIN: VERSION 2

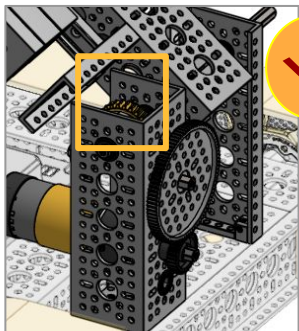
- ▶ **Solution: Custom plate** at the bottom to prevent electric shorts & **house the control/expansion hubs**.
- ▶ **O-drive drivetrain** - no need for space in the front of our drivetrain.
- ▶ **435 rpm motors** to make robot **faster**.
- ▶ **GripForce GoBilda wheels** to improve traction.
- ▶ **Guards** to prevent samples from being caught.

ELBOW

GOALS

Pivot the arm for deposit into the **high basket & high chamber**

VERSION 1



V1

- ▶ **Worm gear** reduces stress on the motor and has **28:1 gear ratio**
- ▶ **Magnetic limit switch** to prevent the elbow from angling below the drivetrain and to create a home position for proper encoder resets.

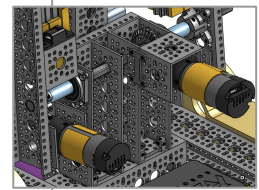
LESSONS LEARNED

Creating mathematical predictions is critical for iteration efficiency.

VERSION 2

- ▶ **Raised the speed** from V1
- ▶ Removed 1 stage of gears and added more connection to drivetrain so **elbow is stable**
- ▶ **Kept Worm gear**
- ▶ Hard stops for consistent homing

V2



CALCULATING TORQUE

$$Torque_{motor} = 86.49 / 28 = 3.45 \text{ kg cm}$$

$$Torque_{motor + worm gear} = Force * Distance = 1.84 \text{ kg} * 47 \text{ cm} = 86.49 \text{ kg cm}$$

$$Force = Weight = 1.84 \text{ kg}$$

We chose a 1150 rpm motor with a worm gear

ARM & ASCENT

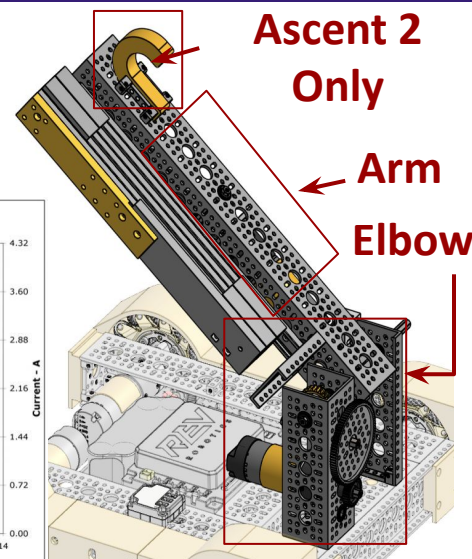
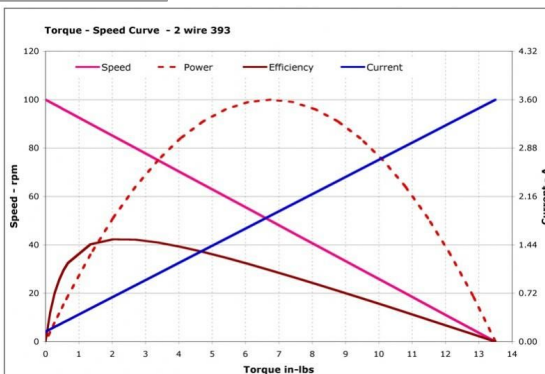
ASCENT GOALS

- ▶ Achieve an **Ascent 2 or 3** in under **10 seconds**
- ▶ Does not interfere with intaking from the submersible

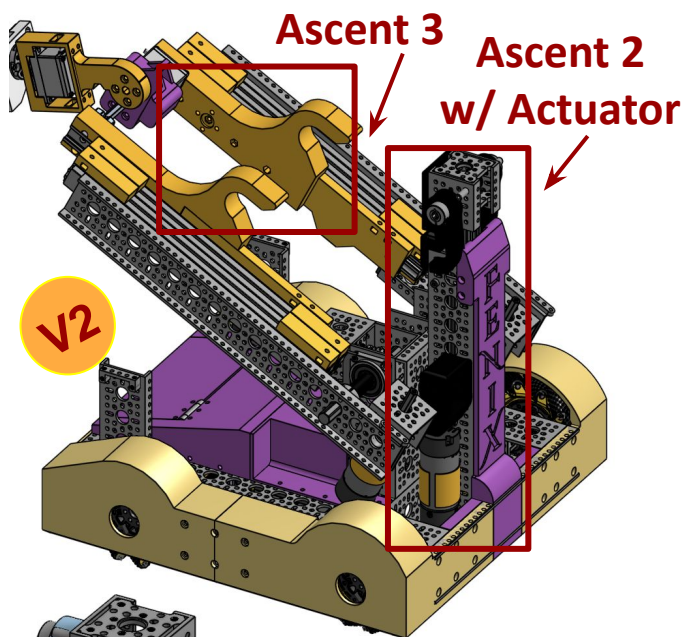
VERSION 1: ASCENT 2 ONLY

$Torque = \delta * \gamma = 205.11 \text{ kg cm}$
 $\alpha = \text{Arm Weight} + \text{Slide Weight} = 1.5 \text{ kg}$
 $\beta = \text{End Effector Weight} = 0.4 \text{ kg}$
 $\gamma = \text{Max Distance from Pivot Point} = 116 \text{ cm}$
 $\delta = \text{Drivetrain Weight} = 5.3 \text{ kg}$

Thus, we chose a **1620 rpm** motor with a **84:1** gear ratio



VERSION 2: ASCENT THREE



ACTUATOR: TORQUE CALCULATIONS

$$T = \frac{Fd}{2} * \frac{\tan(\alpha) + \mu}{1 - \mu \tan(\alpha)} = \frac{86.97N * 0.008}{2} * \frac{\tan(17.65) + 0.2}{1 - 0.2 \tan(17.65)} = 1.97 \text{ kg cm}$$

$$\text{helix angle} = \tan^{-1}(L / \pi d) = \tan^{-1}(8 / \pi * 8) = 17.65^\circ$$

$$F = mg = 8.85 \text{ kg} * 9.81 \text{ m/s}^2 = 86.97 \text{ N}$$

$$d = \text{diameter} = 0.008 \text{ m}$$

We chose an **1150 rpm** motor

ASCENT 3: TORQUE CALCULATIONS

$$Torque = Mass * \delta * \sin(\theta) = 275.2 \text{ kg cm}$$

$$\delta = \text{slide extension to pivot point distance} = 34.4 \text{ cm}$$

$$Mass = Mass_{Robot} - Mass_{Arm} = 8 \text{ kg}$$

$$\theta = 90^\circ \rightarrow \sin 90^\circ = 1$$

Thus, we chose an **435 rpm** motor with an **28:1** gear ratio and **2 counter-force springs**

VERSION 3: ASCENT 2 WITH FASTER SLIDES AND ELBOWS

- ▶ **Linear Actuator** powered by a 1150 rpm motor (math above)
- ▶ Our custom Ascent 3 hooks now **reinforce our Ascent 2**

- ▶ We chose to revert to Ascent 2 for **faster slides and elbow**
- ▶ We score **1 more specimen in endgame** and **3 more specimens in Tele-Op**
- ▶ The change **reduced our ascent time by 60%**

LESSONS LEARNED

Optimizing game strategy and efficiency often requires design compromises.

ENDGAME POINTS TRADE-OFF

Strategy	Cycle Time	Points
Ascent 3 + 1 specimen	20 Seconds + 6 Seconds	40
Ascent 2 + 3 Specimens	8 Seconds + 6 Seconds	45

SLIDES

GOALS

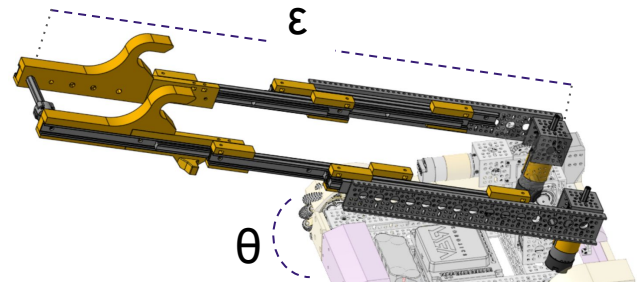
- ▶ **Lightweight** while being **fast and efficient**
- ▶ Reach into the **submersible & high/low basket**

VERSION I: SAR 230'S

- ▶ Prototyped with SAR230 Misumi slides
- ▶ They were 6 stages and **heavy**
- ▶ Weight led to the slides **bending out of shape**



SOFTWARE CONTROLLED STOP



We determine the maximum extension of the slide which is dependent on the elbow angle

$$\theta = \text{Elbow Angle}$$

$$\epsilon = \text{slide length} = 21 \text{ in} / \cos \theta$$

We convert the result into motor ticks

$$\theta = \text{Elbow Angle}$$

$$\epsilon = \text{slide length} = 21 \text{ in} / \cos \theta$$

$$\text{ticks} = \text{EncoderResolution} * \epsilon / \text{Pulley Circumference}$$

$$\text{ticks} = 384.5 \text{ ticks/rev} * \epsilon / 4.72$$

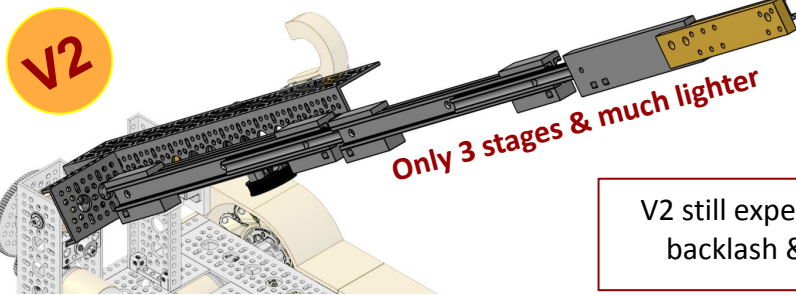
Soft Stop prevents slides from breaking horizontal expansion limit

VERSION 2: SAR 330'S

SLIDE TRADE-OFF ANALYSIS

Slides	Belt / String	Length	Stroke	Cost	COTS / Custom	Weight	Thickness & Sturdiness	Friction
Viper Kit	Belt	336 mm	489 mm	\$112	COTS	882 g	24.4 mm	Mid
Swyft 350	Belt	350 mm	600 mm	\$199	COTS	208 g	48 mm	Low
SAR 330	Both	300 mm	600 mm	\$165	Custom	400 g	60 mm	Lowest
SAR 230	Both	300 mm	540 mm	\$150	Custom	300 g	36 mm	Low

- ▶ Switched to SAR330 Misumi slides due to **low friction**
- ▶ Reduced bending, **slides maintained their shape**



V2 still experienced backlash & play

VERSION 3: 2 SET BELTED SAR 330'S

- ▶ Increased torque and stability
- ▶ Installed a **touch sensor** to establish a home position
- ▶ Squared off slides **eliminate sag**

TORQUE CALCULATIONS

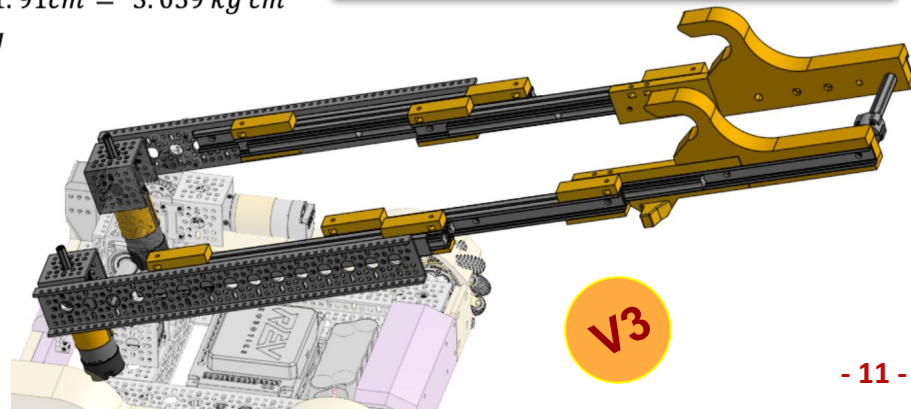
$$\text{Torque} = \text{Force} * \text{Radius of Pulley} = 1.61 \text{ kg} * 1.91 \text{ cm} = 3.059 \text{ kg cm}$$

$$\text{Force} = mg = 1.61 * 9.81 = 15.79 \text{ N} = 1.61 \text{ kg}$$

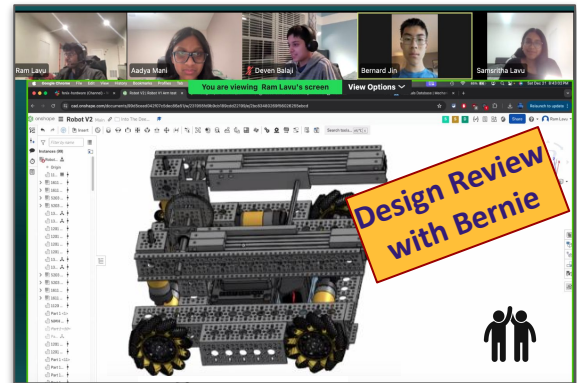
MOTOR TRADE-OFF ANALYSIS

Motor Options	Torque	% of Max Load	Speed
2 x 1620 rpm	10.8 kg cm	28%	Slower
2 x 1150 rpm	15.8 kg cm	19%	Faster

We installed **2 1150 rpm motors** each motor runs at **19% of their max load**, meaning they are faster than using 2 x 1620 rpm motors



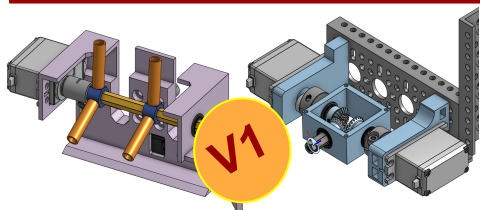
MENTOR - BERNIE JIN



INTAKE

ITERATIONS

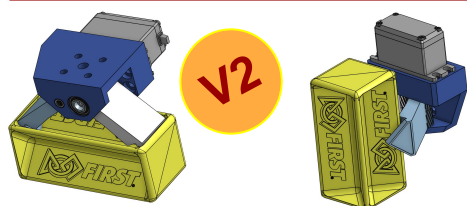
DIFFERENTIAL + ACTIVE INTAKE



TeleOp:
5 Samples

- ▶ Able to pick up only samples in **any orientation**
- ▶ Used a **single system for both intake & deposit**
- ▶ Could not intake or clip specimens
- ▶ **Inefficient in submersible** due to lack of visibility

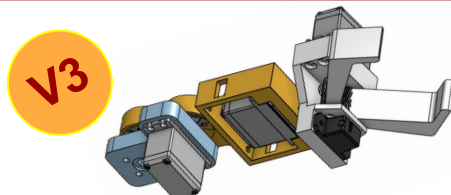
MULTI-GRIP CLAW



TeleOp:
9 Samples

- ▶ Samples can be **picked up from inside & outside**
- ▶ Can both **clip specimens & deposit samples**
- ▶ Uses a light wrist to achieve **2 degrees of motion**
- ▶ Not driver friendly- could not intake parallel
- ▶ Rarely used inside pick-up

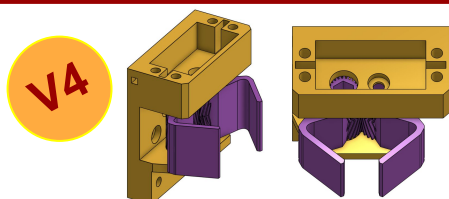
PARALLEL GRAB CLAW



TeleOp:
11 Samples

- ▶ Could intake and exit from the submersible **without changing elbow angle**
- ▶ 300° **Pitch** and 300° **Roll** Wrist
- ▶ Required very **precise alignment** to intake

FLAT WALL-GRAB CLAW



TeleOp:
6 Samples

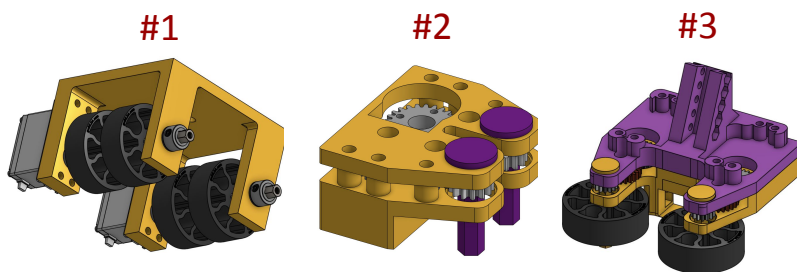
- ▶ Easy to **intake specimens from human player**
- ▶ Couldn't intake from submersible without elbow movement and perfect **perpendicular alignment**

GOALS

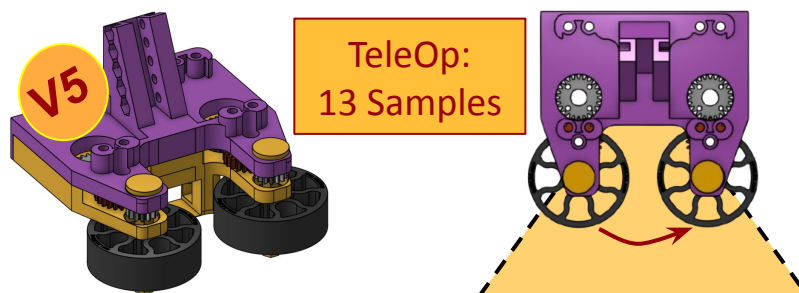
- 1: **Versatile** - Clip specimens & deposit samples in high basket
- 2: **Efficient** - Fast cycle time when intaking in submersible
- 3: **Simple** - No transfer mechanism

SELECTING V5

After the Chesapeake Championship **each hardware team member created their own design** for an active intake. We created CAD prototypes and tested which was most efficient and had the most tolerance. We chose design #3.



VERSION 5:

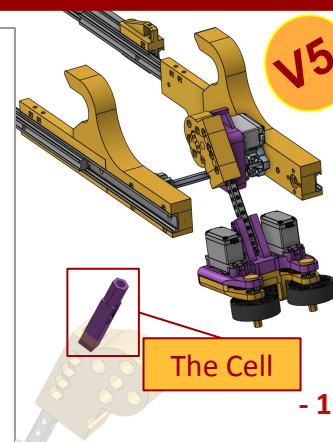


TeleOp:
13 Samples

- ▶ Can both **clip specimens & deposit samples**
- ▶ Forgiving- Can **intake any sample orientation**
- ▶ Uses a **Rev color sensor** to **auto-intake** specimens and samples and **Auto-eject** the opposite alliances samples
- ▶ Efficiency- **Elbow positions does not change** when depositing specimens, facilitating **rapid cycling**

WRIST SYSTEM

- ▶ **300° Pitch arm** mounted with a torque servo
- ▶ **Hard stop** prevents servo from overextending and breaking
- ▶ **Easy to adjust length** and improve orientation
- ▶ **"The Cell"** is an extension to our wrist which scores Ascent 1 in auto **without harming servo**



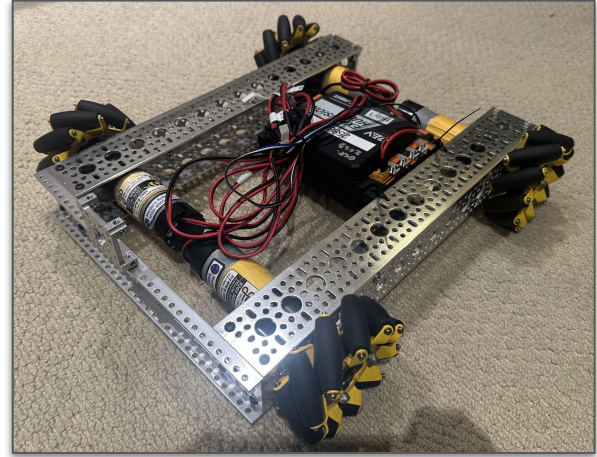
The Cell

SOFTWARE DESIGN PROCESS

DESIGN

- ▶ Identified **software requirements** for auto and tele-op
- ▶ Initial prototype software developed using Blocks to test HW prototypes
- ▶ Used **flowcharts** and **pseudocode** to map out the logic
- ▶ Identified **tools** and **libraries** to use
- ▶ Once hardware was finalized, switched coding of auto & teleop to Java with frequent code iterations
- ▶ Organized code into **modules for each hardware component**
- ▶ Each HW subsystem has a **dedicated unit testing teleop**
- ▶ Instituted peer review by adding a **pull request template** to all merges to main branch requiring a peer to approve
- ▶ Started with basic controls and **iteratively added** more **enhancements**
- ▶ Used standard telemetry and **custom logging** for profiling and debugging the code
- ▶ Software **mentors helped with design reviews**, code reviews and proper object oriented coding
- ▶ Tools Used: Github, SourceTree, Android Studio, FTC dashboard, RoadRunner, MeepMeep, Miro, Slack, Trello


SOFTWARE TEST BOT



VERSION CONTROL

- ▶ Used **github** to store our code
- ▶ **One master branch** for the combined auto and teleop code
- ▶ Each team member wrote and tested code in **individual branches**
- ▶ Merges into the master branch required pull requests to be **peer approved**
- ▶ All configuration files and design notes were checked in as well

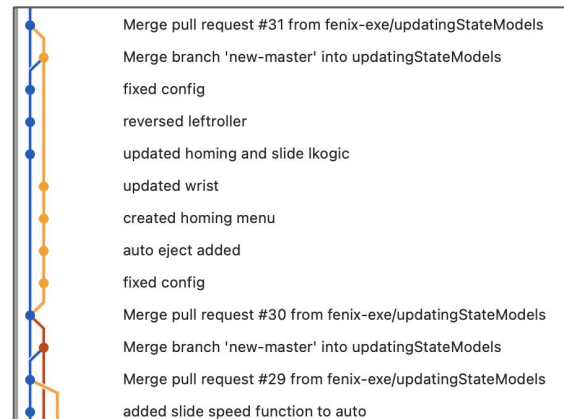
LESSONS LEARNED

- ▶ **Coach Pankaj, Mentor Dr. Balaji helped us think through proper object oriented design & architecture** 
- ▶ It helps the SW team to have a semi-functional **dedicated software robot** that can be modified to test different functionality like odometry

- ▶ When there is an issue in the robot -

"SW is always guilty until proven otherwise." 

- ▶ Merge conflicts were frequent and caused a lot of wasted time until we started using **pull requests & separated out code into different class files**.
- ▶ Proper use of Java interfaces allowed us to handle HW changes more easily.
- ▶ Blocks code is very useful for rapid testing and we benefited by using both and not relying only on Java.



AUTONOMOUS

AUTO GOAL

Consistent & High-Scoring Autonomous: deposit 5 specimens or 5 samples during every march.



INNOVATIVE INTERPRETER

To boost the efficiency of development and testing, and to ensure the reliability of autonomous operation, we've developed a **novel interpreter**. This interpreter **translates human-readable auto sequences** (pseudocode) from a **CSV file** into robot commands, **eliminating the need for Java code changes**. It's fully integrated with our robot's systems, including Roadrunner for **path planning**, Pinpoint for **localization**, and our suite of custom **subsystems**. Our mentor, Sully, taught us **how to read and parse CSV files**.



X	Y	Angle	Elbow	Elbow Speed	Slide	Pitch	Roll	Claw	Wait	Comment
-7.5	65	0	1700	1	0	0.7	0.2	1	0	Starting
-7	65	0	36	1	6.4	0.1	0.2	1	0	Initial Pos
-7	25.5	90	80	1	6.4	0.1	0.2	1	0	Go To Clip 1
-7	25.5	90	80	1	6.4	0.1	0.2	1	0	Clip 1st
-7	25.5	90	80	1	13	0.1	0.2	1	0	Clip 1st
-7	25.5	90	80	1	13	0.55	0.2	0	0	Clip 1st
-7	25.5	90	80	1	1	0.55	0.2	0	0	Clip 1st
-7	30	90	80	1	1	0.55	0.2	0	0	Push Blocks
-43	30	90	0	1	1	0.55	0.2	0	0	Push Blocks

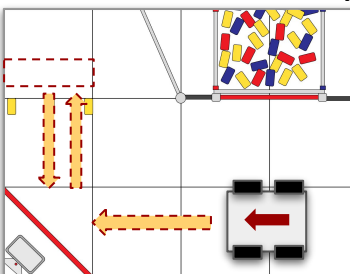
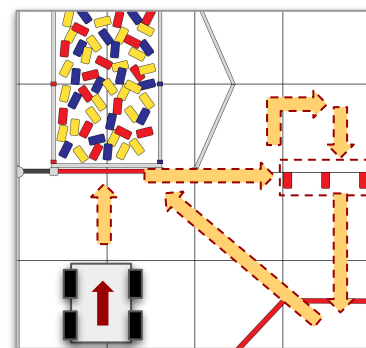
ROADRUNNER

- ▶ We compared Roadrunner's **"splines"** and **"strafeTo"** movements.
- ▶ We integrated our interpreter and pinpoint odometry with Roadrunner.
- ▶ We **improved Roadrunner** by adding error and velocity corrections.

	"splines"	We chose "strafeTo"
Strength	Curves	Straight paths
Weaknesses	Fast movements	Complex movements
Characteristics	Always a curve	Always a straight line
We Noticed	Extra movements	No extra movements

Strategy #1: Clip 5 Specimens on High Chamber

- ▶ 1 Specimen pre-loaded; 1 in observative zone
- ▶ 3 Samples pushed into observation zone then clipped on high chamber
- ▶ Park
- ▶ **Goal: 5 x 10 + 3 = 53 points**



Strategy #2: Deposit 4 Samples into High Basket

- ▶ 1 Sample pre-loaded
- ▶ 3 Samples into High Basket
- ▶ Ascent 1
- ▶ **Goal: 32 + 3 = 35 points**



ODOMETRY

We compared **dead wheel odometry** and the **GoBILDA Pinpoint Odometry Computer**. We concluded that the pinpoint is superior (accurate, easier to use), so we implemented it in our robot.



Trade-Off Analysis	3 Dead Wheel	Pinpoint	Best
Axial Gain	15	3	Pinpoint
Lateral Gain	10	5	Pinpoint
Heading Gain	8	5	Pinpoint
Top Speed	70 in/min	100 in/min	Pinpoint
Drift (144 in)	2	0.5	Pinpoint
Percent Drift	1.39%	0.35%	Pinpoint

LESSONS LEARNED

OPTIMIZATION

- ▶ Created a **custom interpreter** to change autonomous positions without having to re-upload code.
- ▶ The outcome was **efficient software development** and it was easy to iterate our code, especially when tuning at competitions

ROADRUNNER

- ▶ During the season, the software team **learned how to plan paths** in RoadRunner.
- ▶ **Optimized Roadrunner** with libraries for **efficient autonomous**.

TELEOP DESIGN

SOFTWARE GOALS

- 1: Automations in Tele-Op:** Provide drivers with predefined sequences of robot behaviors to minimize manual control.
- 2: Code Modularity:** Easily debuggable and adaptable to hardware adjustments & iterations.
- 3: Configuration Driven:** All preset values and constants are read from external file allowing easy adjustments.

- ▶ **Subsystems:** Encapsulate & abstract away related actuators/sensors & expose their interface to the modules.
- ▶ **Modules:** implement their controls (i.e. soft limits) & expose their interfaces to user-triggerable actions & **Finite State Machines (FSMs)**.
- ▶ **FSMs:** Each FSM uses module APIs to interact with encapsulated subsystem-relevant logic (i.e. preset/automated sample intake).
- ▶ **All Layers:** Independently testable & have **extensive debug logging into a file** which we use for **post game analysis**.

Unique Driver Enhancements

- ▶ Drivers **use only 1 button to go through an entire state machine**. Each press moves to the next state when user input is required **making driving easier**.
- ▶ Duplicate controls for sample intake on both gamepads to allow driver who has better view inside the submersible to intake.
- ▶ Each FSM ends by positioning the slides and elbow for the most probable next state.

MODULAR ARCHITECTURE



Interpreter Input / Driver Control



Finite State Machines (FSMs)

Code Modules

Drivetrain

Arm

End Effector

Subsystems

Slides

2 motor,
touch sensor

Elbow

1 motor,
magnetic limit
switch

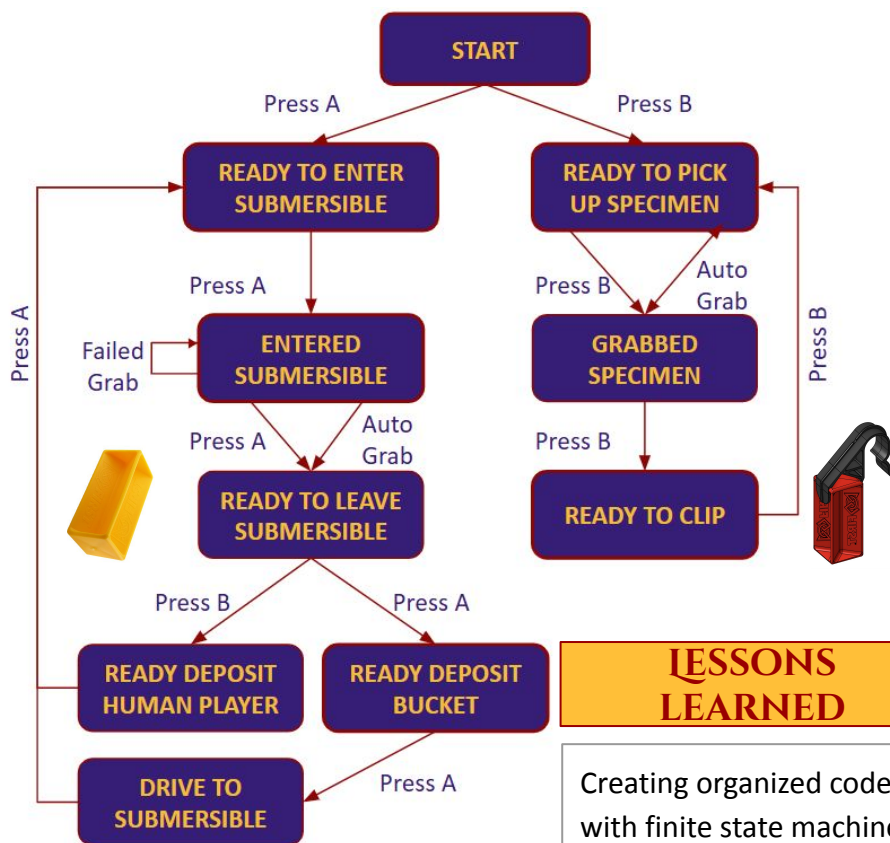
Wrist

1 servos for
pitch

Intake

2 servos,
distance sensor

TELEOP FINITE STATE MACHINE



LESSONS LEARNED

Creating organized code with finite state machines and minimal button variation is critical for driver efficiency during gameplay and making quick enhancements off the field.

OPTIMIZING LOOP CYCLES

Problem: Slow loop cycles in Tele-Op created lag for drivers

Initial Speed: 15 Loops / Sec

- ▶ Reduced I2C Reads
- ▶ Switched to bulk reads
- ▶ Removed multi-telemetry
- ▶ Minimized hardware delays

Final Speed: 45 Loops / Sec

3x Faster

25865

FeNiX.EXE

IGNITE THE PASSION

