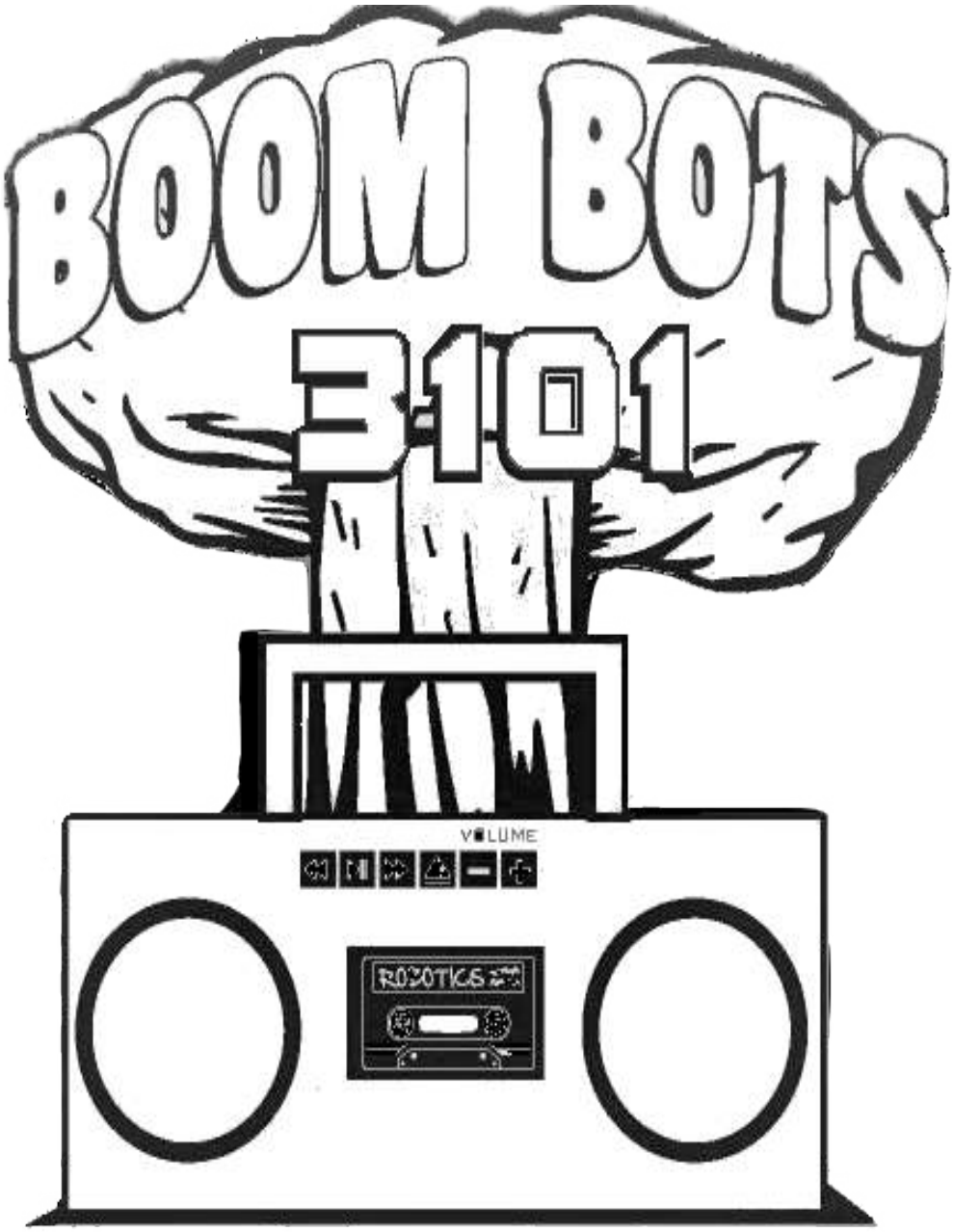
Season Summary



Team 3101: Boom Bots

2019 - 2020 Season: FIRST SKYSTONE

Team Summary

Team 3101 Boom Bots is from Palm Harbor University High School in Palm Harbor, Florida & has been an FTC team since 2008. Last year, we were the **ROVER RUCKUS World Champions** after becoming the **Winning Alliance Captain at the Houston World Championship.** We are 1 of 5 FTC teams from the PHUHS Robotics Club and have 8 members.

The Robot

This is the most custom robot we have ever built in 13 years as a club with **every part being hand machined by our build team and the entire robot designed in CAD before assembly**. We were the **1st team in all of FTC SKYSTONE to stack 11 high in a match** (mid-November) and have since repeated it. Featuring unique, elegant, and robust designs including our **multi-compliant wheel intake, pass-through system, and extremely low-center-of-gravity drivetrain**, we have never fallen below 8th in the world out of 7,000 teams internationally! In reference to our program for this season, we've created a code more elaborate than ever. Our autonomous is smoother than ever with **all-new power curves and intelligent mid-motion correction**. Keeping with our ideology of driver-controlled enhancements being just as important as autonomous, **nearly every action of the tele-op is automated** or made easier to control.

Outreach

Our team recognizes the great benefits of enriching the community through STEM education; thus, we have **held over 37 outreach events this year with over 150 cumulative hours**. These include events like **starting a robotics program in India, hosting robotics talk-shows** to educate rookie teams and provide recaps for events, attending community events to fundraise and spread FIRST, as well as **hosting booths at entrepreneurship conventions** to network and gain new sponsors.

Business

Our team this year is comprised of 8 members, including 4 seniors, 3 juniors, and a freshman, only 3 of which were on 3101 last year. We've taken new members this year to train them for future years.

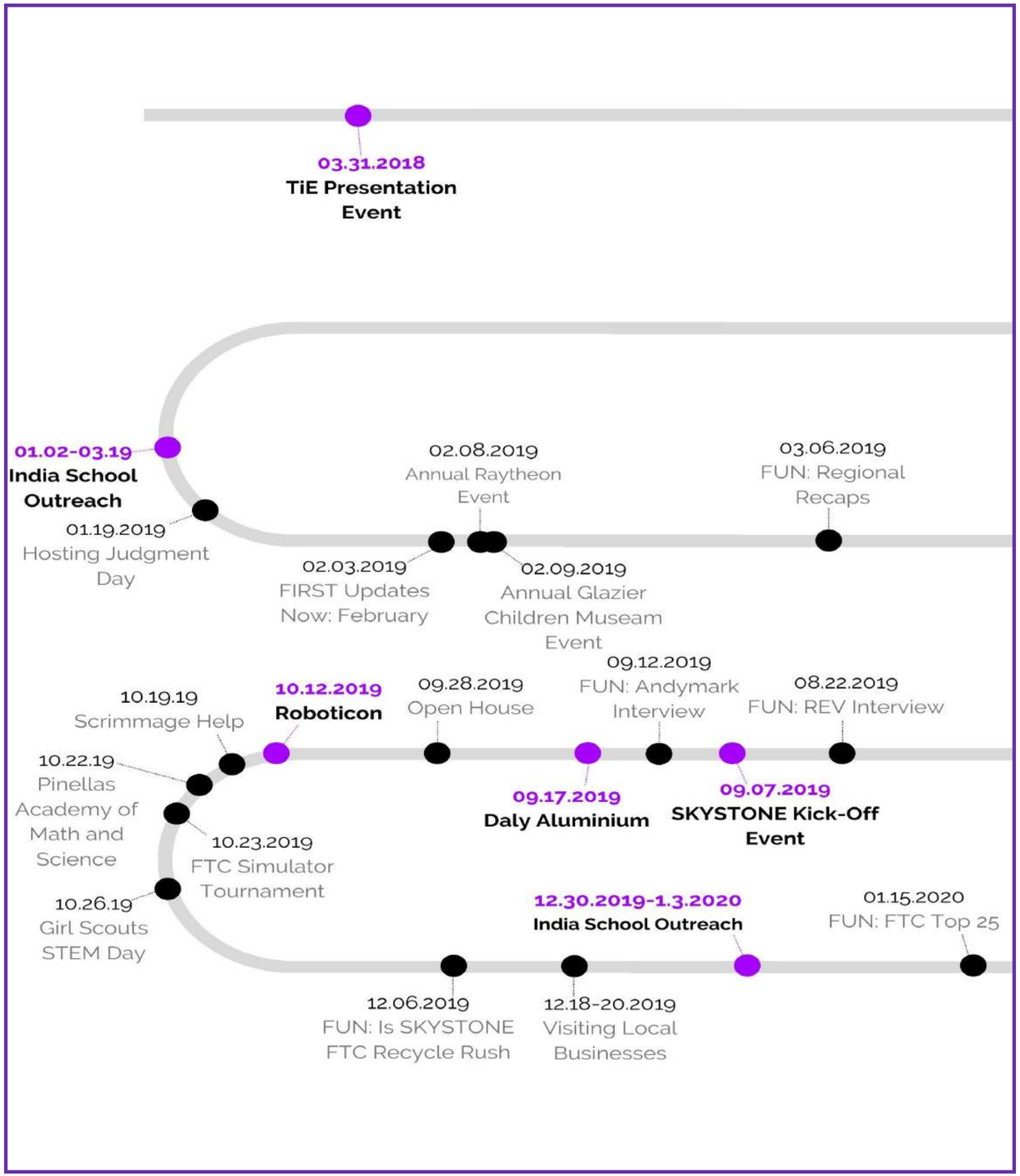
This year, we have **15 different sponsors**, many who joined after we won the World Championship. We gain new sponsors and sustain the club through **sponsorship packages, donation flyers, business cards, and connecting with the community** at all possible times. As a team, we have **raised over $8000 in the past 2.5 years.** At every competition we attend, we make sure to help at least 2 rookie teams, with one of our members developing long-term relations with a new rookie team this year.

Outreach

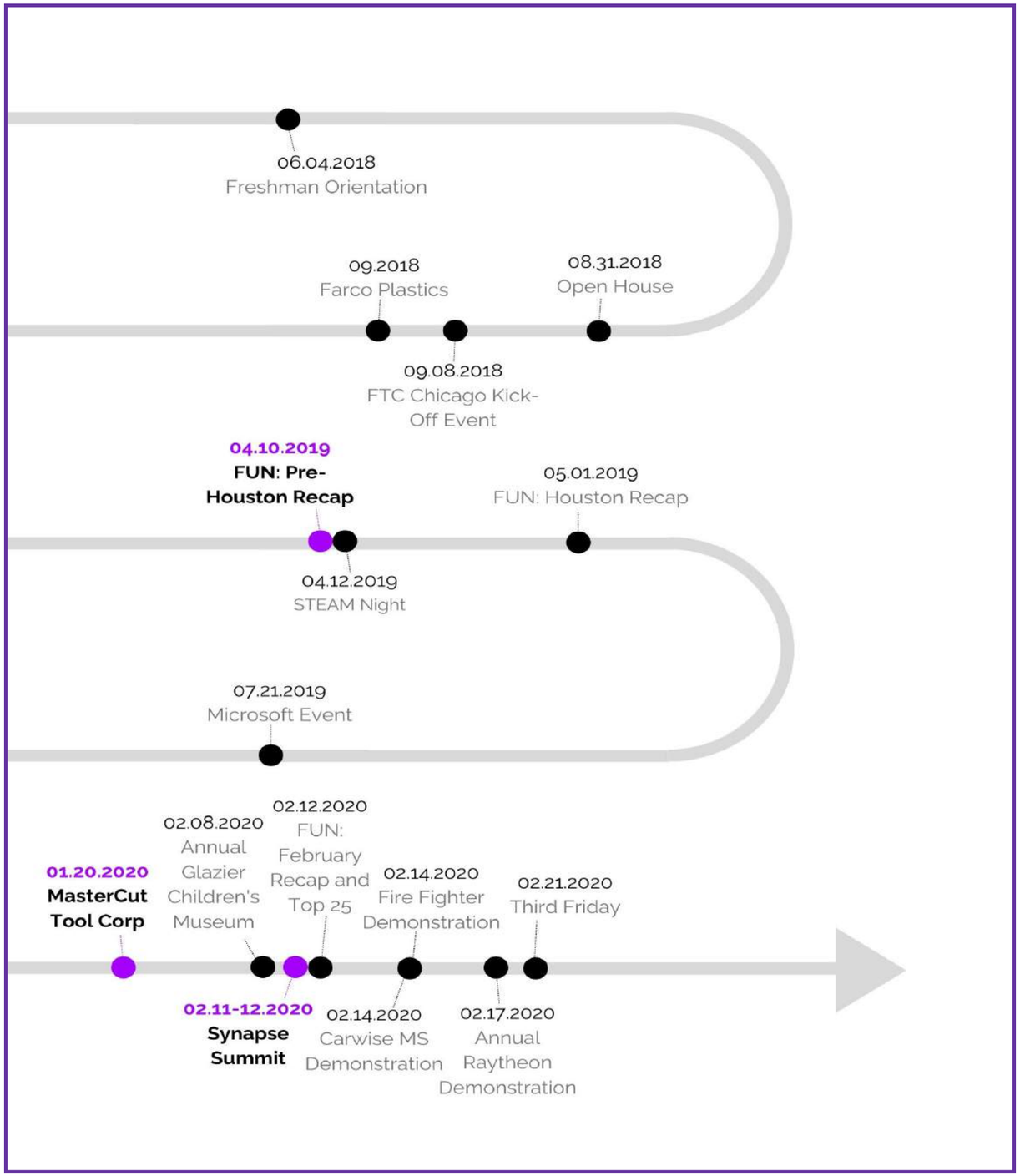
An essential part of any FIRST Team, outreach is something we heavily focus on. **This season we have gone above and beyond with more outreach events that had larger impacts than any of our previous seasons.** We realize and embrace the fact that through outreach we are able to inspire the future generations of engineers and connect with experienced members of the STEM community.

In the past 2 years, as a team, we have hosted **over 37 outreach events, extending our touch to the local, national, and global community**. Through demonstrating at local businesses, hosting talk shows, working with firms, and starting robotics programs in international countries, we have seen the impact outreach has on FIRST, others, and us. These 37 events have accumulated over 150 hours just spent in outreach. I**ncluded in our season summary is a timeline of all of our outreach events in the past 2 seasons and documentation of our most impactful outreach, starting a robotics program in India.**

Outreach Timeline



Outreach Timeline



India School Outreach

| 12.30.2019-01.03.2020 | Jaipur, India |

28th Outreach Event

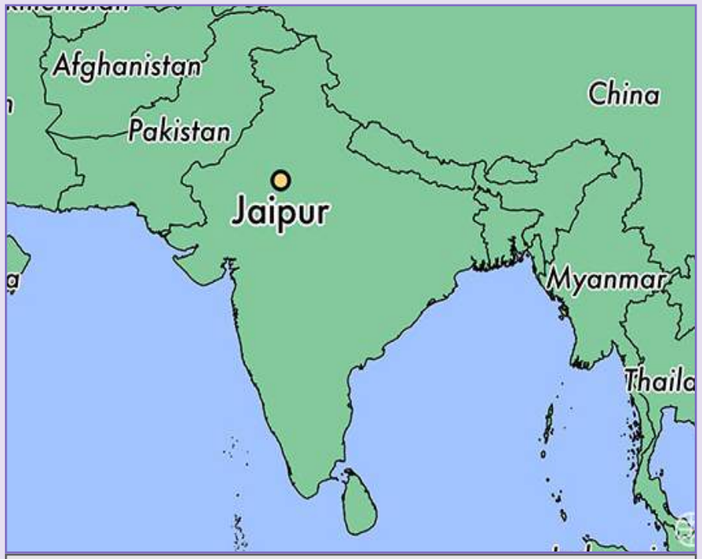
50+ people impacted

20+ total Hours

105 Cumulative Hours

Overview

For the second year in a row, over our winter break Dominik and Aabhas spent one week at an underprivileged school in India. While there, they taught the students the essentials of robotics giving them classroom and hands on time allowing the students to not only learn about also develop their own engineering skills. Over the course of 5 days Aabhas and Dominik taught the students the basics of programming and CAD. This trip was a follow up to when Aabhas started this program last year, and he returned this year to check in and further develop their skills. There were 6 to 20 kids per day and they worked 3 to 6 hours per day on programming and CAD. We already have plans to return next year!



Location of the event, Jaipur, India is Aabhas' birthplace and hometown

What We Learned

- The differences between opportunity in India and here in the US is huge
- Students are eager to learn about new and fun subjects
- It is okay to go over concepts multiple times

Aabhas teaching CAD to a student

Aabhas speaking to the entire school about FIRST

How We Spread *FIRST*

- Brining FIRST to a school in rural India
- Teaching less privileged kids engineering and robotics essentials
- Spreading the mission of FIRST past our own boarders

Accomplishments

- Establishing a long-term presence for PHUHS Robotics in the international community
- Introducing a new community to FIRST, FTC, and CAD software
- Teaching others the foundations of programming and CAD

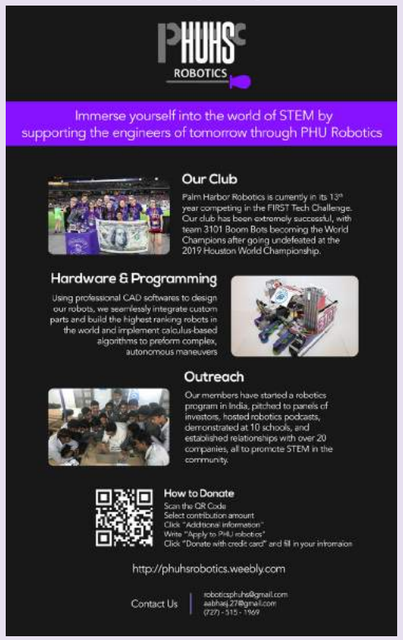
Sponsors

The operations of an FTC team can be quite expensive, so every year it is necessary that we find sponsors to support our progress throughout the season. This year we have especially focused on finding new sponsors through the creation of various sponsorship materials. These include professional letters, our first ever sponsorship package, and flyers to keep the community, and potential sponsors informed and excited about team 3101 Boom Bots.

The sponsorship flyer gives a brief overview of the PHUHS robotics club and is distributed at community events like 3rd Friday in Safety Harbor downtown. It has proven especially useful in reminding people of what PHUHS robotics is about after we meet them and has our contact information, as well as instructions to donate included on it.

The sponsorship package gives a more complete view of PHUHS robotics and was developed this year as a tool for first-year members to use especially to more easily garner sponsorships. The package includes a summary of our club, FIRST, an overview of the community impact we've made, outreach we've done, information about our engineering process, as well as a summary of our budget, and the different tiers of sponsorships we have.

All of these sponsorship materials have been made by our team, 3101 Boom Bots, for the entire PHUHS Robotics Club, and in this year's season summary we have included our sponsorship package on the following pages.



2019-20 Sponsorship Overview: PHU Robotics

Summary

PHU Robotics is a high school robotics club with 5 teams competing in the FIRST Tech Challenge (FTC) from Palm Harbor University High School in Palm Harbor, Florida. Formed in 2007, we have competed at the local, state, and world championship levels and currently are comprised of 70+ members. Our 5 teams are: 506 Pandara, 516 Gears of Fire, 3101 Boom Bots, 3830 Violet Fusion, and 3839 Mechanical Geniuses. In the past two years, PHU Robotics won 20 awards at 6 different competitions with over 40 nominations. At the World Championship last year, one of our teams, 3101 Boom Bots, went undefeated and won the whole championship, becoming the 2019 World Champions.

Our Mission is to nurture creativity, inspire innovation, and ignite young minds while promoting STEM and the principles of the FIRST organization in the community.

- We **LEARN** through teamwork, communication, and collaboration with technical and non-technical mentors
- We **INSPIRE** elementary and middle school students through demonstrations
- We **SHARE** our passion for robotics and STEM through podcasts, presentations, and public events
- We **CONNECT** with the community at local festivals, entrepreneurship conferences, and personal tours

To run a successful club and outreach programs, **our budget is $12,925 with $21,900 required for the World Championship**, which we have attended 3 years in a row. PHU Robotics is seeking sponsors to help spread STEM to underprivileged communities, younger students, and local businesses. The success of FIRST and PHU Robotics is dependent on the contributions from generous donors including large corporations and private donors.

FIRST Organization – For Inspiration and Recognition of Science and Technology

FIRST, a 501(c)(3) non-profit organization, was founded in 1989 by Dean Kamen to inspire young people's interest and participation in science and technology. **The mission of FIRST is to inspire young people to be science and technology leaders** by engaging them in four exciting mentor-based programs that build science, engineering, and technology skills, which inspire motivation and foster well-rounded capacities including self-confidence, communication, and leadership. The sequence of FIRST programs in the United States begins with the FIRST LEGO League Jr. programing serving elementary school-aged students (ages 6-9), followed by FIRST LEGO League program serving primarily middle school students (ages 9-14), the FIRST Tech Challenge (FTC) serving grades 7-12, and FIRST Robotics Competition, serving grades 9-12. In the 2019 FIRST Longitudinal Study, FIRST reported that **over 575,000 students participated in its programs with more than 51,000 robots created.** For more information on FIRST, please visit www.firstinspires.org

Community Impact and Outreach

Connecting with the Community

- Expanding STEM at many community events including multiple booths at 3rd Friday in Safety Harbor, FL.
- Presentations at entrepreneurship conferences in front of 200 entrepreneurs at TiECON Florida and holding a booth at Synapse Summit 2020.
- Demonstrations at the Children's Glazier Museum, MOSI, St. Joseph's Hospital, and facilities of our sponsors.
- Technical presentations at FIRST events including FTC SKYSTONE Kickoff and ROBOTICON Tampa Bay.

Engaging with the Education System

- Starting a robotics team at Largo High School.
- Demonstrating robots to the vast majority of charter schools in Pinellas County and many public elementary and middle schools.
- Assisting the Girl Scouts of West Central Florida with STEM day and presentations to the Boy Scouts of America.
- Planning a summer robotics program to ease the transition for FIRST LEGO League Students to FIRST Tech Challenge.

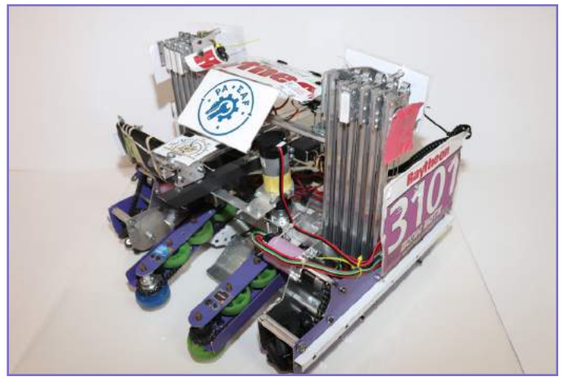
International and Virtual Outreach

- Started a robotics program in Jaipur, India, teaching underprivileged students mechanical, CAD, and programming skills for 2 years. At the end of 2019, 2 students spent 10 days working with the students there on an Arduino-based robot and more.
- Hosting robotics talk-shows on FIRST Updates Now where one of our members interviews game designers and major vendors, while also recapping competitions.

Engineering

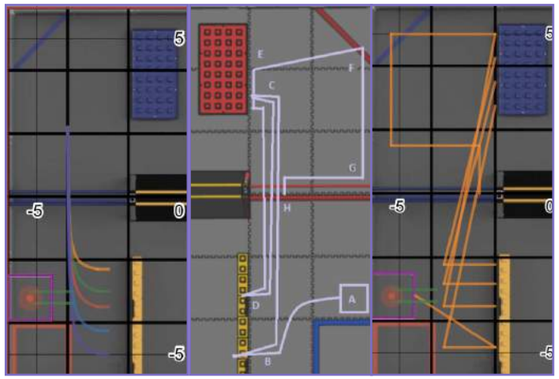
Mechanical Design

- Use of professional Computer Aided Design (CAD) software to design our robots.
- Seamless integration of custom parts consisting of aluminum, polycarbonate, and other raw materials .
- Focus on aesthetics as well as robustness of design.
- Average robot cost is between $1500 - $2000.
- Highest ranking robots in the world as a result of smooth design and fabrication process.



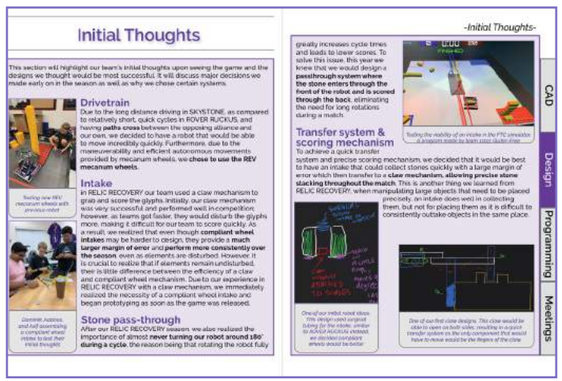
Software

- Industry-standard engineering control loops to ensure precision and accuracy.
- Complex tracking modules and mathematical algorithms to determine the robot's field position with complete confidence.
- Custom computer vision and machine learning models to analyze randomized field modifications
- Multi-step driver automations for ease of control and improved efficiency in driver controlled modes.



Engineering Documentation

- Complete documentation of the team's journey over the season.
- Extensive detailing of robot design, assembly process, and software implementation
- Includes a team business plan, budget, and displays sponsors.
- Documentation of all team outreach events, sustainability plan, and fundraising efforts.



Budget Summary

It is important to remember, any donation to PHU Robotics does not support just one FTC team. All donations are shared among all 5 teams and thus, the club budget can be quite large.

Required Budget: In order to compete in regional and state tournaments, our club will need $12,925 to register, purchase team shirts, purchase robot parts, purchase field elements, and the new electronics system that is being released next year.

Additional Budget: Our club has had teams advance to the Houston World Championship for the past 3 years, we will need an additional $21,900 for the club's travel expenses, registration, and school sponsor expenses.

Expenses	Required Budget	Additional Budget
Registration for FIRST	$1,375.00	$0.00
Registration for Events	$2,000.00	$2,000.00
FTC Field	$450.00	$0.00
Robot Parts	$5,000.00	$200.00
Robot Electronics	$1,500.00	$100.00
Team Shirts	$1,100.00	$200.00
School Sponsor Expenses	$400.00	$1,400.00
Travel Expenses	$1,100.00	$12,000.00
Lodging Expenses	$1,000.00	$6,000.00
Total	**$12,925.00**	**$21,900.00**

Please contact us at roboticsphuhs@gmail.com for a more detailed budget with justifications and our teams' full Business Plan.

Sponsors

Your contribution to PHU Robotics and its 5 FIRST Tech Challenge teams is not just a contribution to a group of dedicated high school team members, but also a donation to the community. PHU Robotics works tirelessly to promote STEM and FIRST to the young engineers of our community and create awareness among students regarding this program. Your donation will amplify your STEM support by investing in a robotics club that is committed to inspiring younger generations of thinkers. By sponsoring, you will have access to the next generation of communicators, engineers, leaders, and team players. Sponsorship can come in many different forms: monetary, parts, credit for product, mentorship, or an invitation for us to visit your company.
We would like to thank our previous season's sponsors. Without their support, we could not have won the Winning Alliance Captain award at the World Championship and Inspire Award at the Florida State Championship.

Sponsorship Levels

Sponsorship Benefits	Supporter ($100-$249)	Silver Sponsor ($250-$999)	Gold Sponsor ($999-$1999)	Platinum Sponsor ($2000+)
Logo in our competition documentation	•	•	•	•
Mention on our website at level of sponsorship	•	•	•	•
Appreciation posts on club and team socials	•	•	•	•
Extensive mention in our competition documentation		•	•	•
Logo on competition banner		•	•	•
Signed team shirts		•	•	•
Small Logo on robot			•	•
Monthly club updates			•	•
Demonstration at company or facility			•	•
Organization description and link on our website				•
Large logo on robot				•

Sponsor Us

For further information on PHU Robotics, feel free to contact us via the below information. We would appreciate the opportunity to present our Business Plan and answer any questions you may have regarding our team, community outreach, engineering, sponsorship benefits, our budget, etcetera. We have incorporated Tampa Bay Technology Alliance, a 501(c)(3) organization, to receive tax-deductible donations on our behalf. We are always looking for experts, mentors, and sponsors to help with our mission. You are welcome to attend one of our meetings and we are happy to visit you.

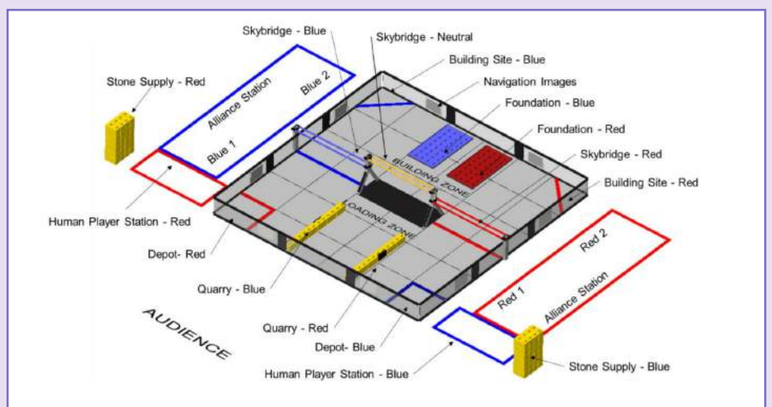
Website: phuhsrobotics.weebly.com
Club email: roboticsphuhs@gmail.com
Instagram: @roboticsphuhs
Treasurer: Aabhas Jain
Treasurer's email: aabhasj.27@gmail.com
Treasurer's phone: (727) 515-1969

The Game

Every year, FIRST designs a new game for the FIRST Tech Challenge, with this year's game having a theme of city-building, named SKYSTONE. The game is divided into two distinct periods, a 30 second autonomous period and a 2 minute TeleOp driver-controlled period. The last 30 seconds of the driver controller period are considered Endgame in which a team can complete special objectives to earn additional bonus points. There is one scorable object in this year's game, the stone. Teams play in alliances of two, facing two other teams, resulting in the red and blue alliance.

This year's autonomous game objectives include: delivering 2 special skystones, placing stones on the foundation, moving the foundation into the build zone, and parking underneath the skybridge. The skystones are randomly placed among 4 other stones, but must be at-least 2 stones apart. They are sampled using custom camera detection.

The TeleOp period involves stacking stones as high as possible for 2 minutes and then placing a team-specific capstone in the final 30 seconds of the match for an extra bonus. Finally, team's may earn additional points for moving the foundation out of the buildzone and then parking inside of it.



SKYSTONE Field Diagram

Skystone

Final Capstone

Design Introduction

In the 13 years our club has existed, this is the **most custom robot ever built.** All of our custom parts this year were designed, fabricated, and machined by our team, something we are extremely proud of.

Being a veteran team has given us the capabilities and experience to embark on this mission, while also teaching the new, freshman builder on our team. We believe that designing a fully custom robot requires **much more ingenuity** and **creativity**, overall resulting in a very **streamlined, efficient, and high-scoring robot.** When designing and building our robot this year, we followed a 7-step process:

1. **Strategizing & Defining Parameters**
2. **Researching**
3. **Drawing & Prototyping**
4. **CADing**
5. **Fabricating**
6. **Testing**
7. **Iterating**

As a result of this process, we were able to design and build an incredibly reliable and high-ranked robot this year. Furthermore, **every major component of our robot** this year was either **first designed in CAD or highly detailed in a drawing before being fabricated**, ensuring i**ncredibly compact, precise, and reliable systems**. At the end of the year, our robot's costs totaled to $2,451. Our robot's most notable functionality relies on four major systems. The season summary includes our documentation of initial thoughts regarding the game, diagrams of our full robot and individual subsystems. The subsystems are as follows:

1. **Drivetrain**
2. **Intake**
3. **Lift**
4. **Claw**

Initial Thoughts

This section will highlight our team's initial thoughts upon seeing the game and the designs we thought would be most successful. It will discuss major decisions we made early on in the season as well as why we chose certain systems.

Testing new REV mecanum wheels with previous robot

Drivetrain

Due to the long distance driving in SKYSTONE, as compared to relatively short, quick cycles in ROVER RUCKUS, and having **paths cross** between the opposing alliance and our own, we decided to have a robot that would be able to move incredibly quickly. Furthermore, due to the maneuverability and efficient autonomous movements provided by mecanum wheels, we **chose to use the REV mecanum wheels.**

Intake

In RELIC RECOVERY our team used a claw mechanism to grab and score the glyphs. Initially, our claw mechanism was very successful and performed well in competition; however, as teams got faster, they would disturb the glyphs more, making it difficult for our team to score quickly. As a result, we realized that even though **compliant wheel intakes** may be harder to design, they provide a **much larger margin of error** and **perform more consistently over the season**, even as elements are disturbed. However, it is crucial to realize that if elements remain undisturbed, their is little difference between the efficiency of a claw and compliant wheel mechanism. Due to our experience in RELIC RECOVERY with a claw mechanism, we immediately realized the necessity of a compliant wheel intake and began prototyping as soon as the game was released.

Dominik, Aabhas, and Asif assembling a compliant wheel intake to test their initial thoughts

Stone pass-through

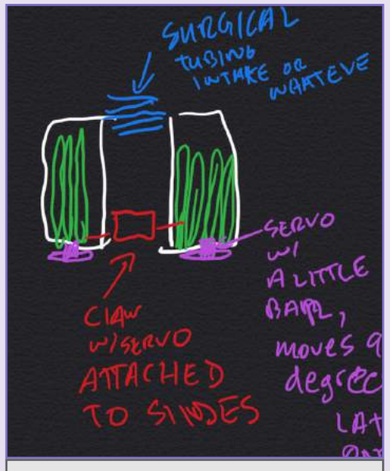
After our RELIC RECOVERY season, we also realized the importance of almost **never turning our robot around 180˚ during a cycle**, the reason being that rotating the robot fully greatly increases cycle times and leads to lower scores. To solve this issue, this year we knew that we would design

a **pass-through system where the stone enters through the front of the robot and is scored through the back**, eliminating the need for long rotations during a match.

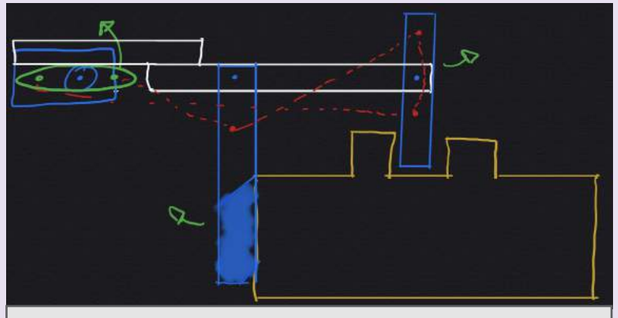
Testing the viability of an intake in the FTC simulator, a program made by team 11115 Gluten Free

Transfer system & scoring mechanism

To achieve a quick transfer system and precise scoring mechanism, we decided that it would be best to have an intake that could collect stones quickly with a large margin of error which then transfer to a **claw mechanism, allowing precise stone stacking throughout the match**. This is another thing we learned from RELIC RECOVERY, when manipulating large objects that need to be placed precisely, an intake does well in collecting them, but not for placing them as it is difficult to consistently outtake objects in the same place.

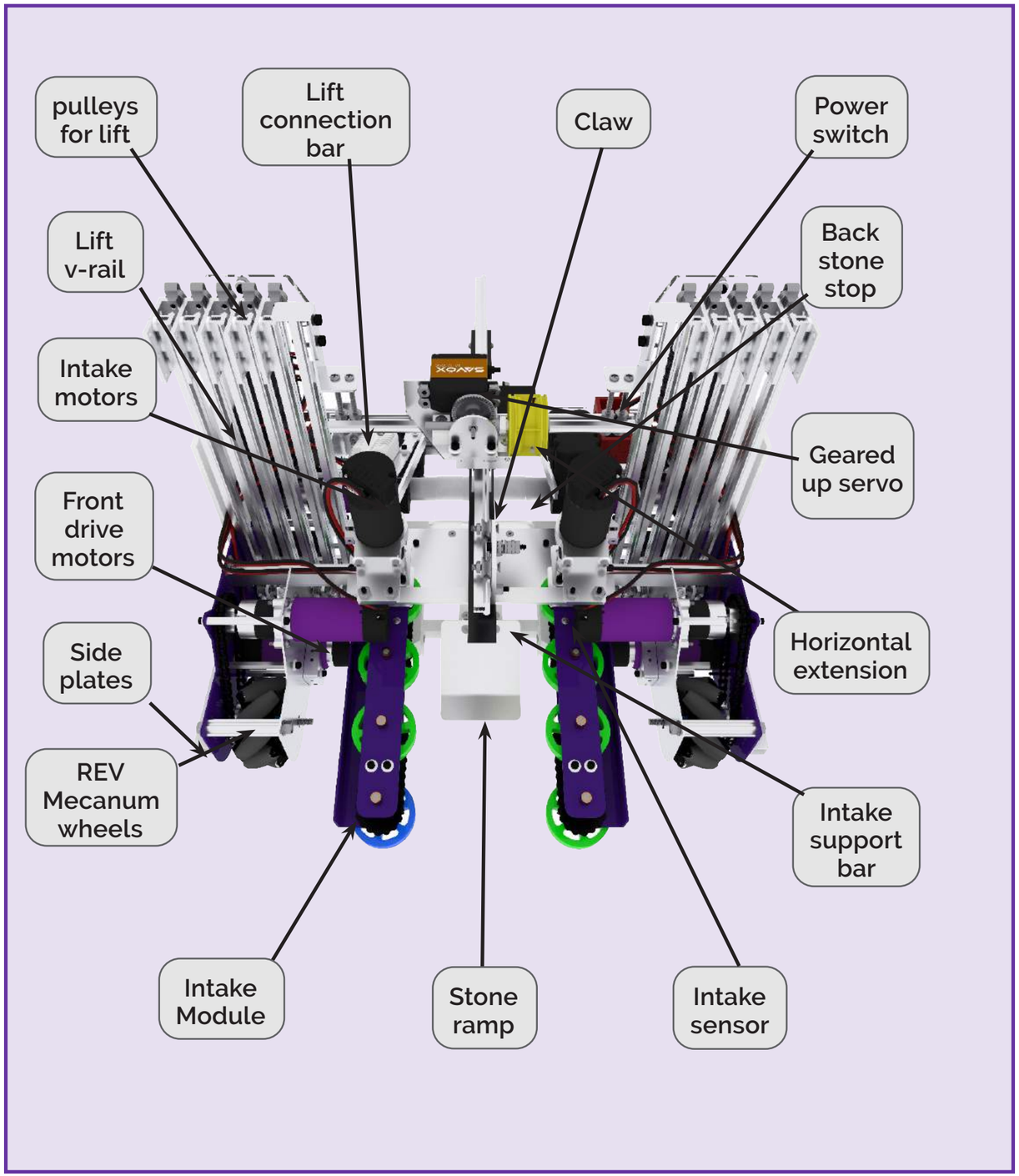


One of our initial robot ideas. This design used surgical tubing for the intake, similar to ROVER RUCKUS; instead, we decided compliant wheels would be better

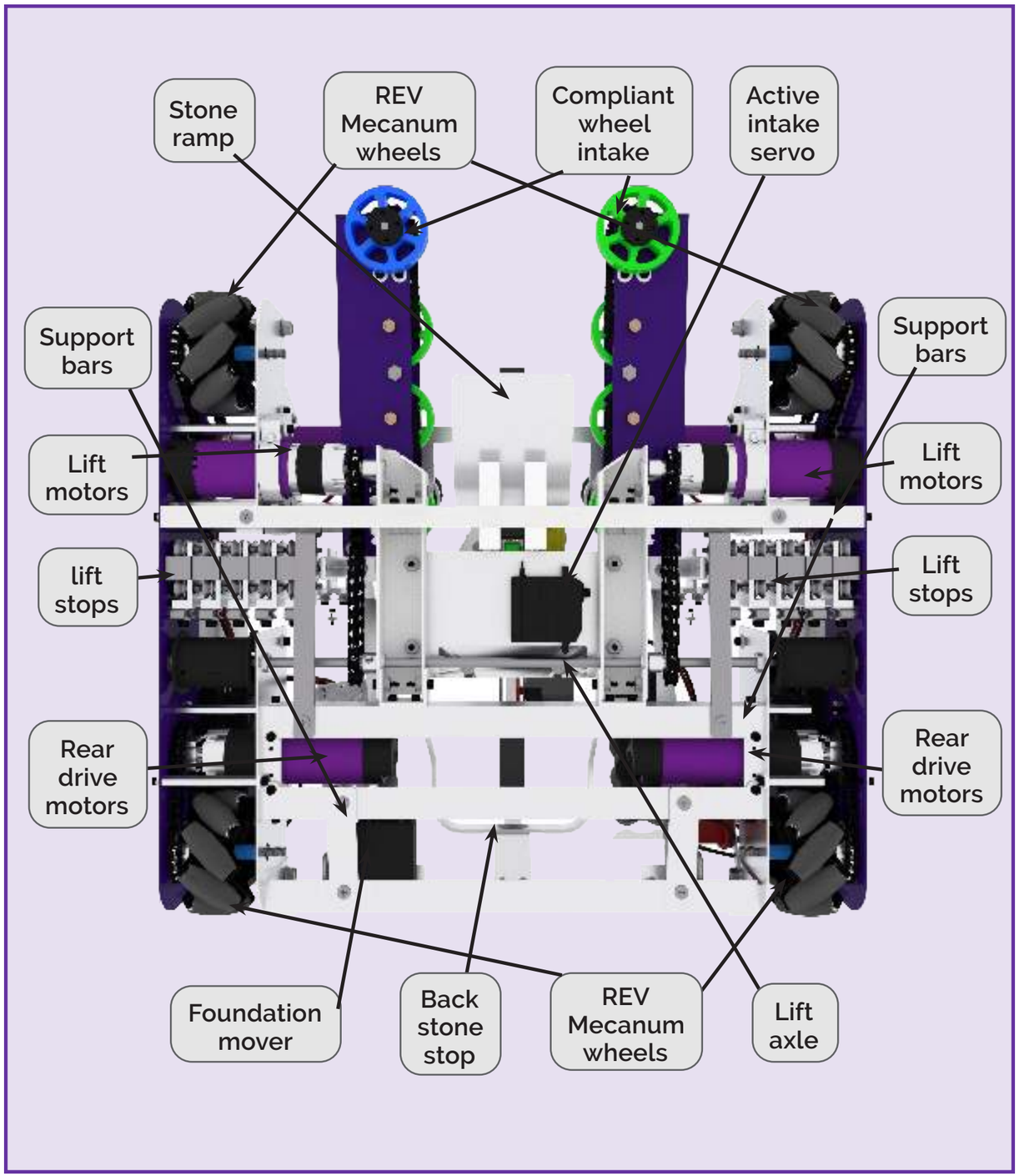


One of our first claw designs. This claw would be able to open on both sides, resulting in a quick transfer system as the only component that would have to move would be the fingers of the claw.

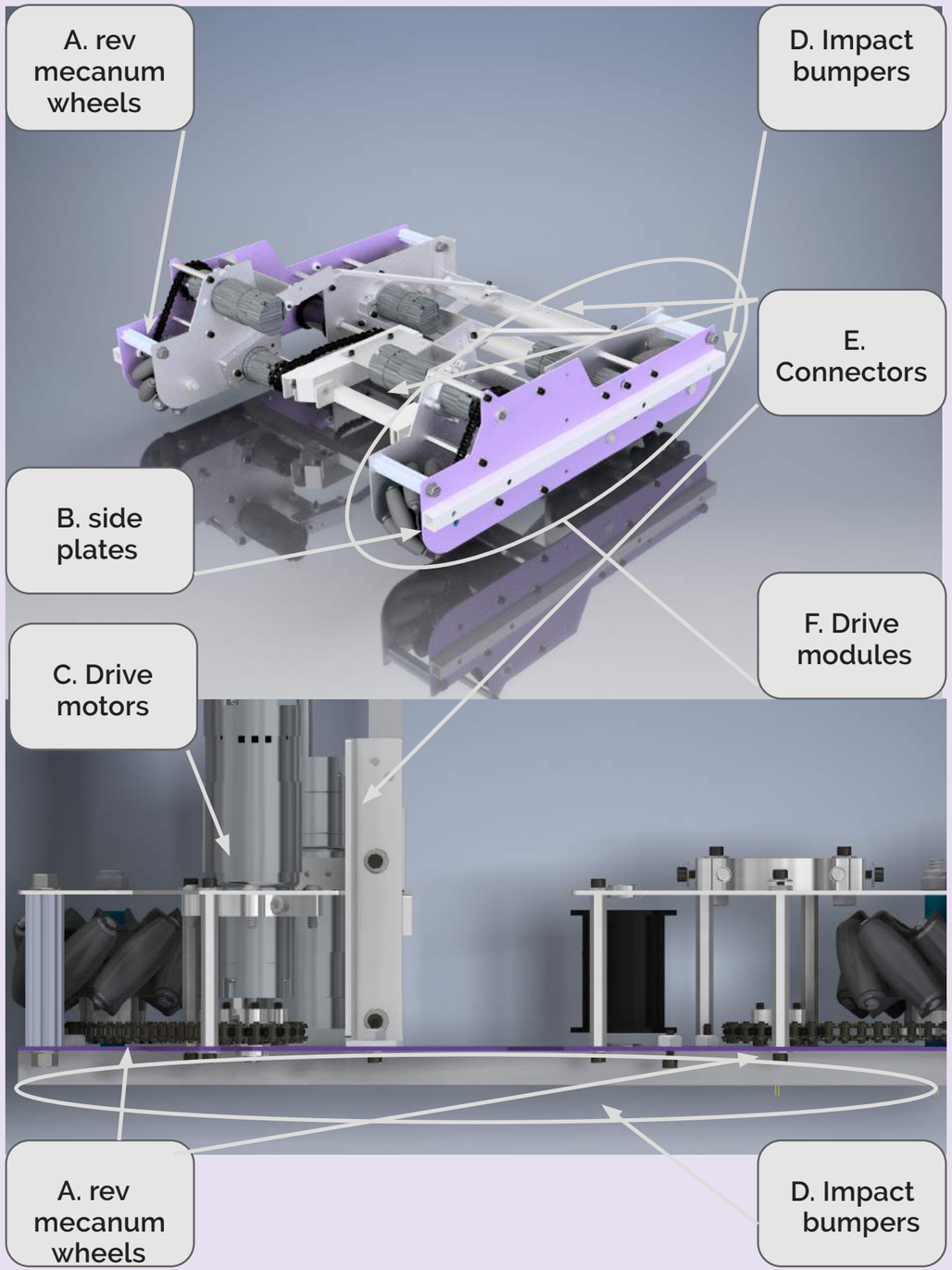
Front View



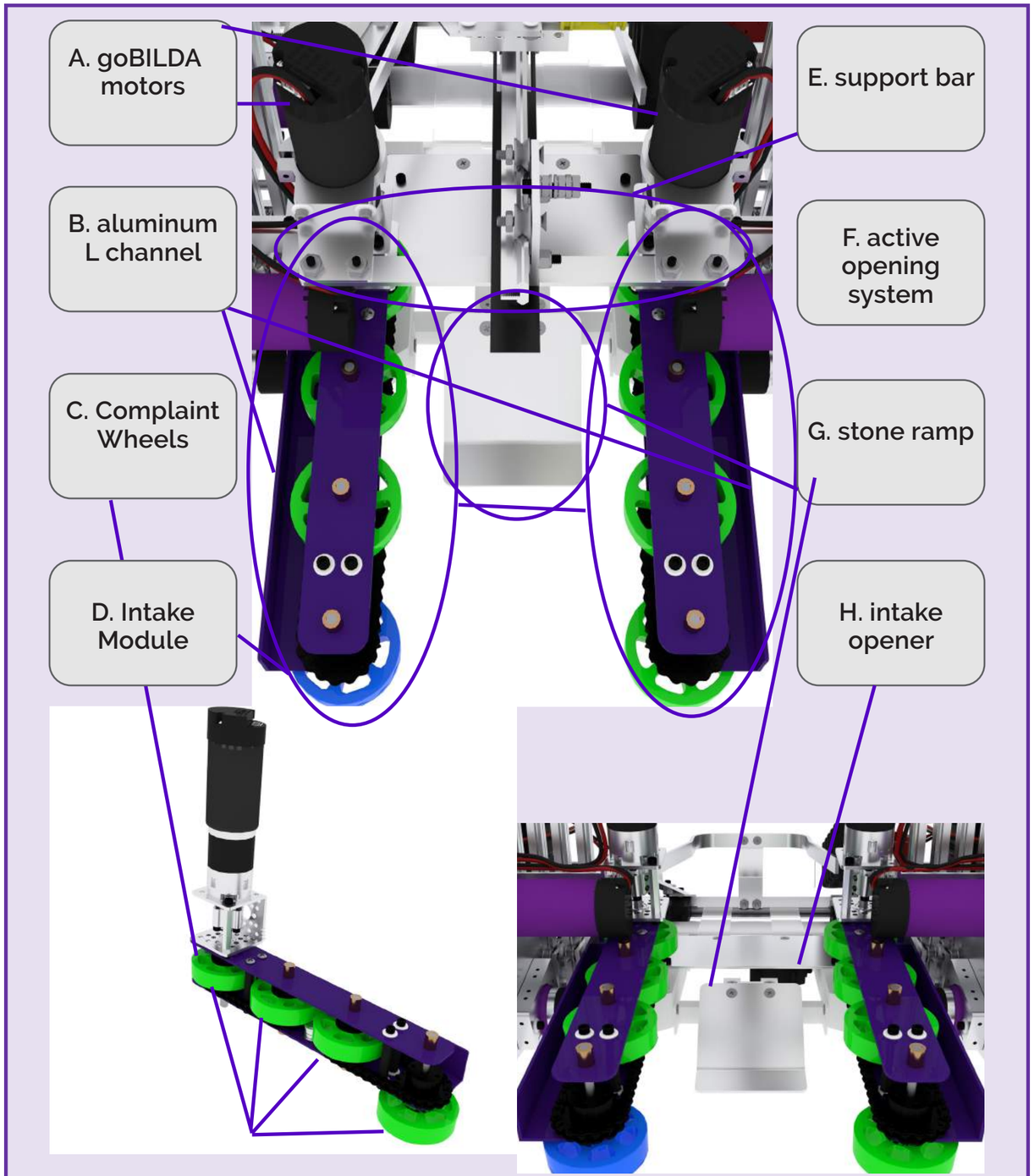
Bottom View



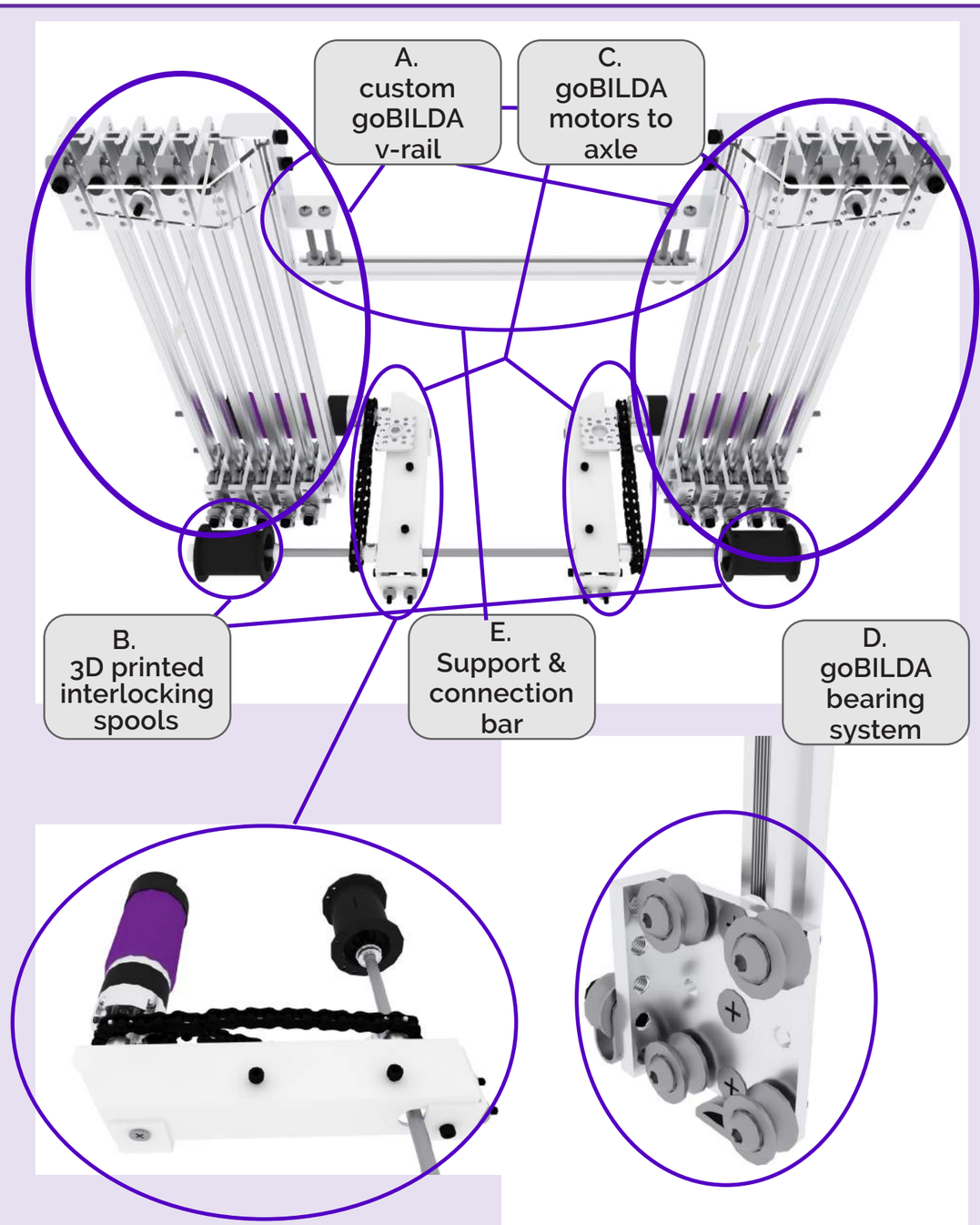
Drivetrain



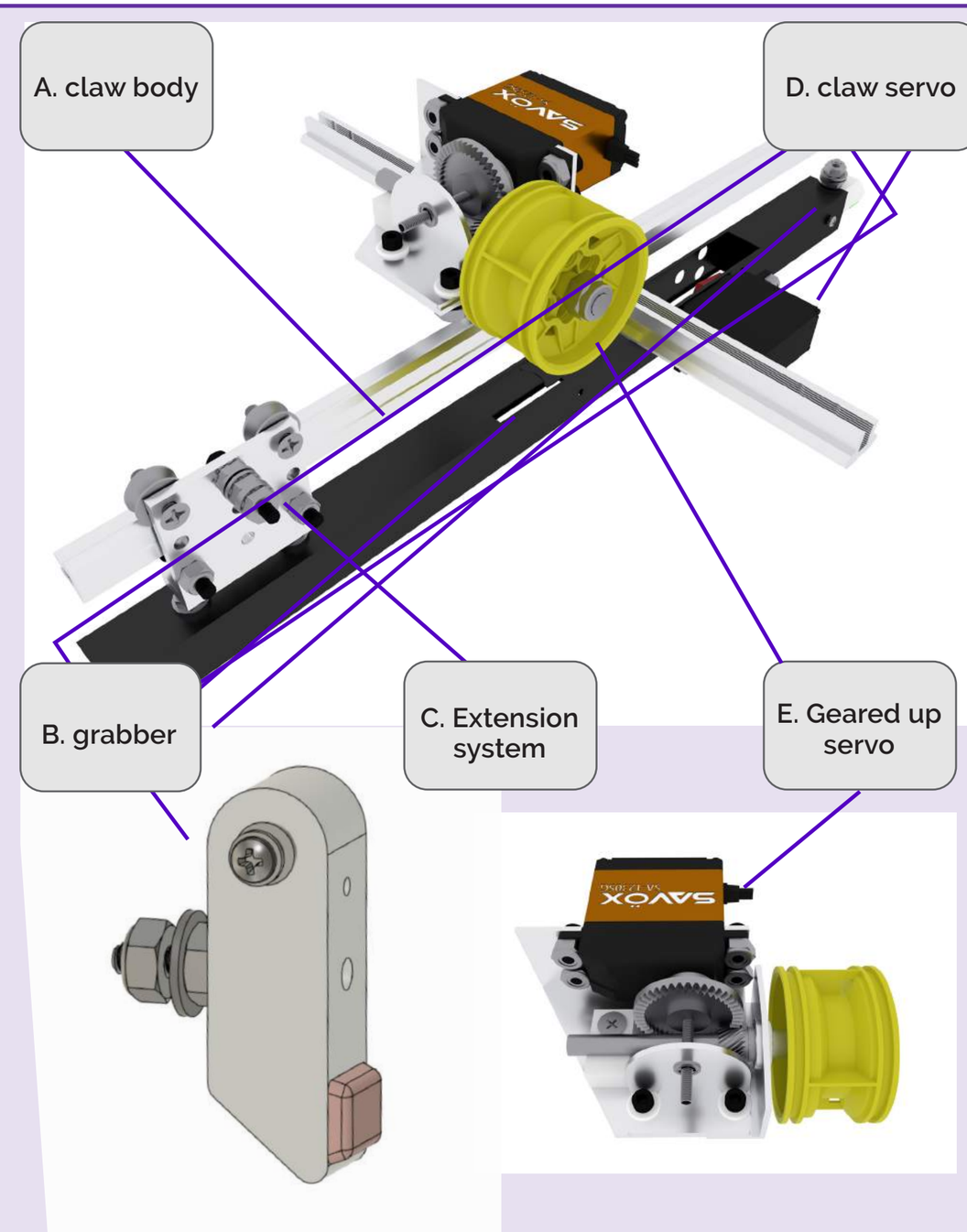
Intake



Lift


A.
custom
goBILDA
v-rail
C.
goBILDA
motors to
axle
B.
3D printed
interlocking
spools
E.
Support &
connection
bar
D.
goBILDA
bearing
system

Claw


A. claw body
D. claw servo
B. grabber
C. Extension
system
E. Geared up
servo

Autonomous Overview

What it does

Our autonomous program is able to consistently score 43-48 points by delivering both skystones, placing twp, repositioning the foundation, navigating to the sky-bridge, and optionally pushing our partner into the navigation zone if they are unable to do so themselves. Not only does it score these points, it also consistently places the stones in an optimal location for further stacking in the driver-controlled period and leaves the foundation perfectly leaving a passage for later pushing against the wall to score in end game.

Walk-through

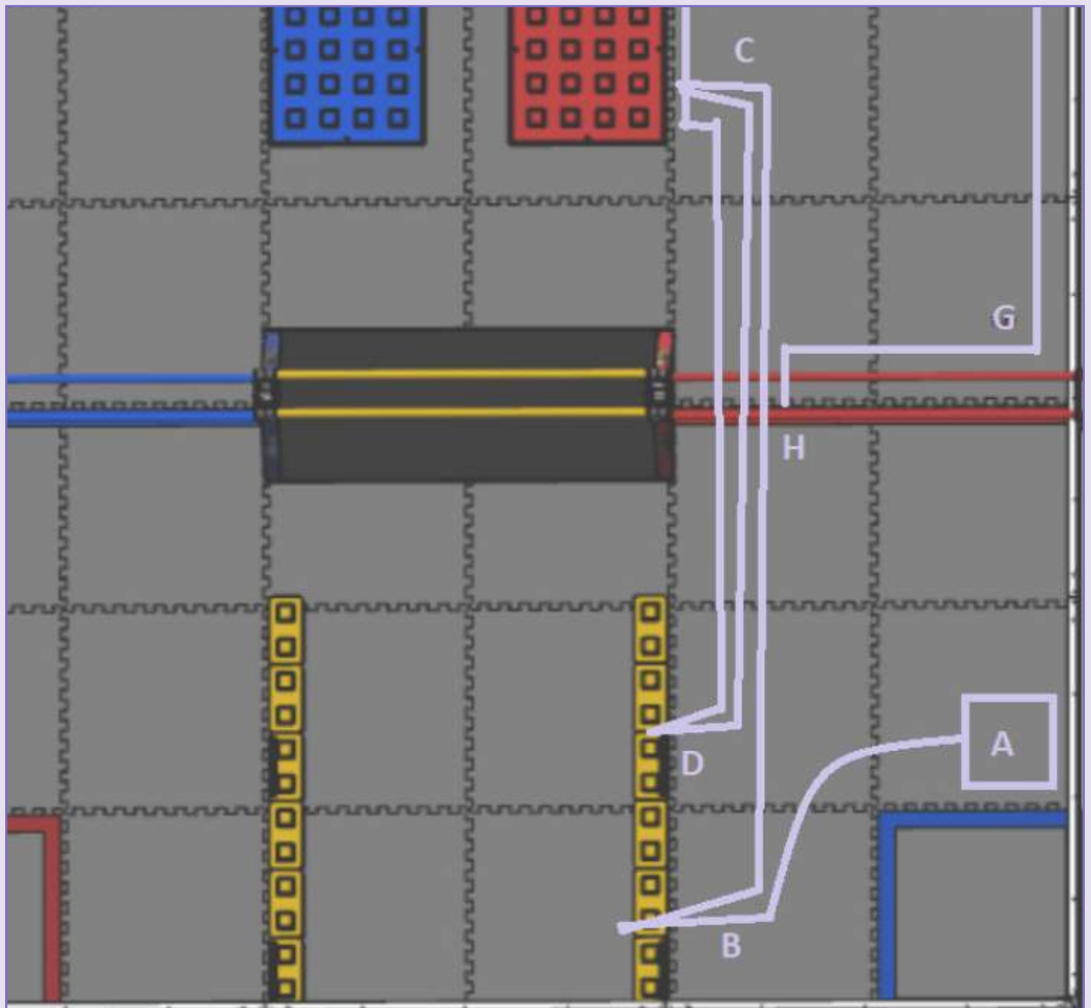
All of our autonomous programs begin the same way:

The robot **starts the game in the loading zone against the wall, as close to the opposing alliance depot as possible**. As soon as the program is initialized, it gets to work attempting to localize the skystones' position. The program runs in a loop checking and re-checking the position in case it has been changed. This allows us to **initialize before randomization**.

Once the play button is hit, the robot quickly makes its way towards the first (audience-side) skystone. On the way, it rotates to a 45 degree angle and then **strafes diagonally into the quarry such that non-skystones are pushed away**, while the skystone enters the intake (which is at this step completely open). The intake closes, the stone is pulled in, and the robot backs out of the quarry. At this point, it rotates towards the build zone, and **uses the rear-facing distance sensor to align at the proper distance** to stack the skystone horizontally on the second spot from the audience. Once at the correct position, the robot rotates and backs into the foundation while lifting and out-taking the stone. P**urposely overshooting the distance, the robot will strafe towards the audience to allow the stone to fall into place**. Now, the robot returns to the loading zone to collect the second skystone.

At this point, the robot moves to the center of the foundation. Hooking on and placing the second stone,, it pulls the foundation in a diagonal path that is such designed that it moves forward and away from the audience into the building site, while simultaneously rotating towards the audience to ensure it doesn't get caught on the field wall. To finish, it strafes out of the area between the foundation in field wall, then moving backwards and to the side to park under the sky-bridge on the side farther from the field wall.

Autonomous Diagram



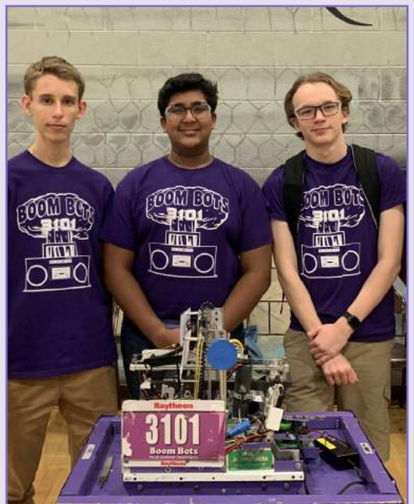
A: Start and skystone detection
B: Collect 1st skystone
C: Deliver and place 1st stone
D: Collect 2nd skystone
E: Hook onto foundation and place 2nd stone
F: Reposition foundation
G: (Optional) Park alliance
H: Navigating

TeleOp Overview

What it does

While "Tele-Op" is often used interchangeably with "Driver Controlled", this name fails to include a large portion of what the last 2 minutes of the game entail. Although the drivers are the ones making decisions, the code is what has to interpret the driver's actions and perform what is most appropriate at that given time. Our **tele-op program is littered with enhancements, assistance algorithms, and even automatic actions in an effort to simplify the complex collection of motors, servos, sensors, and systems into an intuitive and efficient control ecosystem**. While many teams fail to see the power of enhanced Tele-Op code, **our team has spent perhaps more time programming the Tele-Op than even the autonomous**. This has **increased our efficiency tremendously, lowering the amount of things the drivers have to think about and ensuring that they are focused on what really matters.**

Since we firmly believe that the tele-op code is what can truly separate the good from the best, communication between the programming and driving teams must be top-notch. **No one communicates with the drivers better than the coach, so our team's programmer has consistently held that role**, in order to see, hear, and understand how the drivers function on the playing field. It also helps that the programmer is the best expert on how the autonomous functions when discussing with alliance partners.



Our SKYSTONE driveteam

TeleOp Algorithms

Precision Driving

In the beginning, driving was done only with joysticks. However, when maneuvering around field elements and at moments where precision is key, we **found that using the joysticks was difficult and lost time**. To solve this problem, we **now use the dpad and function keys on the game-pad for "precision driving", where the robot moves at 15% max speed**. Additionally, a sensitivity trigger on the right side of the game-pad lowers the sensitivity of all of the controls, more or less depending on how hard the trigger is pressed.

```
rotation = driverGamepad.left_stick_x+(driverGamepad.dpad_right ? 0:-.3)+(driverGamepad.dpad_left ? 0:.3);
vertical = -driverGamepad.left_stick_y+(driverGamepad.dpad_up ? .3:0)+(driverGamepad.dpad_down ? -.3:0);
horizontal = driverGamepad.right_stick_x+(driverGamepad.x ? 0:.2)+(driverGamepad.b ? 0:-.2);
```

Directional Mixer

Another useful function is one that **expands the robot's directional capabilities**. The program adds the right and left joystick input to control the motors to move the robot in any direction while rotating simultaneously.

```
if (Math.abs(horizontal) > threshold) {
    frontRightPower -= horizontal;
    backLeftPower -= horizontal;
    frontLeftPower += horizontal;
    backRightPower += horizontal;
}
if (Math.abs(rotation) > threshold) {
    frontLeftPower += rotation;
    frontRightPower -= rotation;
    backLeftPower += rotation;
    backRightPower -= rotation;
}


frontLeft.setPower(frontLeftPower * powerMultiplier);
frontRight.setPower(frontRightPower * powerMultiplier);
backLeft.setPower(backLeftPower * powerMultiplier);
backRight.setPower(backRightPower * powerMultiplier);
```

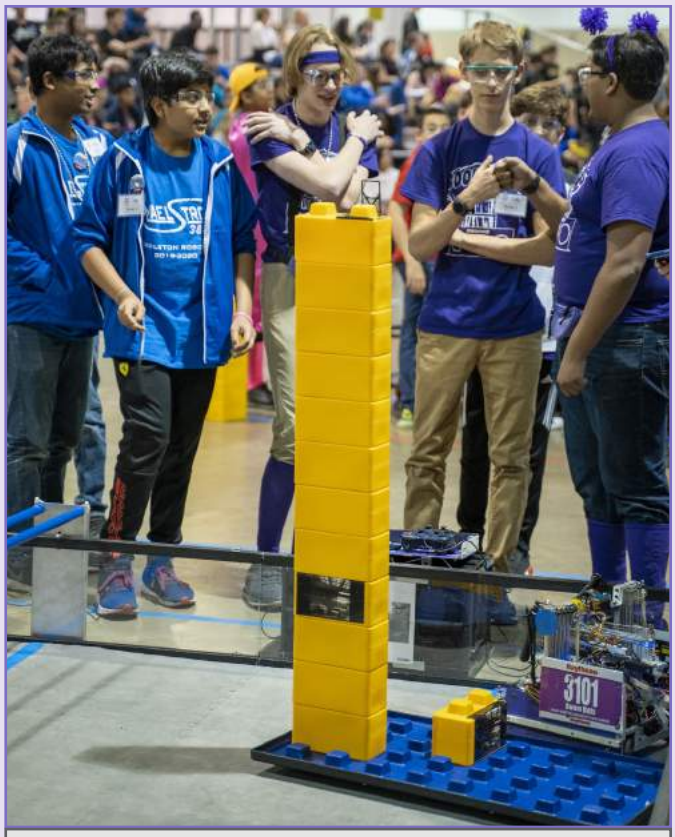
Sensitivity and Power Curves

While a **1:1 power curve for controlling motor speeds** was effective, the drivers found that it **resulted in a power gap at low speeds**. Meaning if the joystick is pressed a small amount, the robot is expected to move slowly, but actually didn't move at all. To solve this, all of our power measurements are proportional to the arctangent of joystick and trigger values. This is used in the primary driver's joysticks (which are used to move the robot), but also on the sensitivity trigger.

```
robot.frontLeft.setPower(Math.atan(frontLeftPower*2.42)*((1.3-driverGamepad.right_trigger)/1.3));
robot.frontRight.setPower(Math.atan(frontRightPower*2.42)*((1.3-driverGamepad.right_trigger)/1.3));
robot.backLeft.setPower(Math.atan(backRightPower*2.42)*((1.3-driverGamepad.right_trigger)/1.3));
robot.backRight.setPower(Math.atan(backLeftPower*2.42)*((1.3-driverGamepad.right_trigger)/1.3));
```

Accomplishments

Although this season may not have had the end our team expected, it was nothing short of an incredible experience. At the Gulf Coast Robotics League Championship, we were nominated for 4 different awards and were the **Winning Alliance Captain after 22 wins and 1 loss over 4 meets**. Then, at the **Florida State Championship we were undefeated in qualification matches** at the Scott Division, and ended as the Scott Division Finalist Captain. Furthermore, at the Florida State Championship we were **nominated for 3 awards, and won 2**: Inspire Award 3rd Place, and Motivate Award 1st place, leading to us **qualifying for the Houston World Championship for the 3rd year in a row**! Finally, for the **first time in our team's history**, we had a Dean's List nominee who became a **Dean's List Finalist after being 1 of 4 winners at the Florida State Championship out of 55 competitors**. The Dean's List award recognizes members of the FIRST Tech Challenge who demonstrate exemplary passion and effectiveness in achieving the mission of FIRST, through mechanical skills, leadership, and entrepreneurship. **Overall, this season team 3101 Boom Bots did incredibly well and had high hopes for the Houston World Championship.**



Celebrating after setting a world-record stack at the Florida State Championship