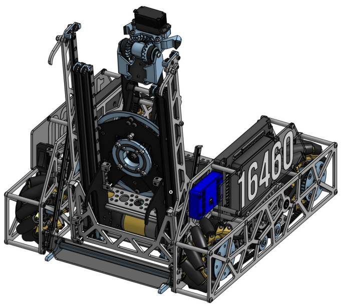
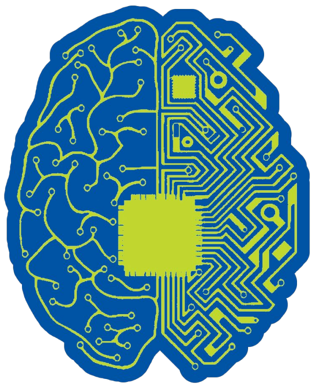
# Engineering Portfolio

## *Team #16460 GEarheads*



### *FTC World Championship*
### *April 2025*

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# We are GEarheads

| Team #16460 | 8 years | 6 years | 15 | 7-12th | 9 |
|---|---|---|---|---|---|
| *Brookfield, Wisconsin, USA* | *FIRST* | *FTC* | *Members* | *Graders* | *Student Mentors* |

## The GEarheads Mission:

Maximize the growth of our team's skills, our impact in the community, and our innovations through teamwork and problem solving.

***2024: Create a strong and sustainable team with an unique presence and impact in our robot performance and community outreach***

*2022: Grow sustainable outreach*

*2023: Grow impact in FIRST*

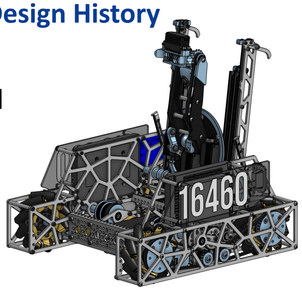
*2020: Improve Robot & Software skills*

*2021: Develop Impactful outreach*

*2019: Build a good Robot*

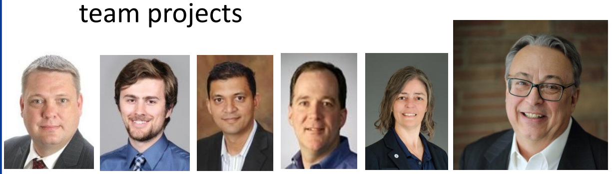
## Goal #1: A World-Class Robot

- *as of Mar 3rd* Holding the **10th Highest OPR** in the world
- Leveraged **Industrial Design History Framework**
- **Innovative** mechanical & software elements
- **Compatible** with both sample and specimen strategies




## Goal #2: Strengthen Sustainability

- Grow our technical skills and outreach capability by connecting with **49+ community mentors (36 new this year)**
- Develop **9 new young student** mentors to replace graduating seniors with focused team projects



## Goal #3: Grow FIRST WI and FTC

- Advocated with **State legislators and and school district**
- Focused on developing **structured support** for FIRST across the state
- Advocated for **$4.5 million expansion** to the WI DPI grant with the Wisconsin Advocacy committee

## Goal #4: Drive Meaningful Outreach

- Impact **1000s with our outreach projects** and events
- Outreach focused on **technical skills, spreading FIRST** in the community, and **developing opportunities for others**

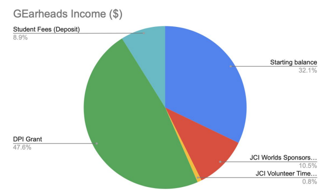
# GEarheads Plans

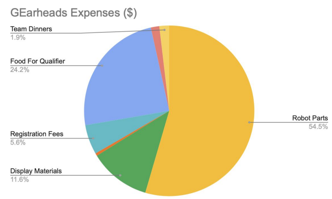
*__MOTIVAT__ing our team to success*

## GEarheads Finances and Budgeting

Our team knows that managing clear financial accountability is important to supporting our development and growth as a team

- **Funding Sources**: Primarily supported by sponsors, DPI grants, donations, and student fees.
- **Strategic Investments**: Funds allocated to technical development, display materials, tools, registration fees, and event-related costs, including food and team dinners.
- **Financial Tracking**: Operates a detailed system to monitor all income and expenses.




## Our team's Sustainability plan

**Sustainability Plan**: Focused on recruiting and developing younger team members through structured projects.

- **Active Recruitment**: Engages potential members at local STEM Expos.
- **New Additions**: Welcomed nine student mentors—Dante, Roman, Aryav, Benjamin, Anirudh, Shloka, Tanvi, Dirk, and Manav.
- **Impactful Contributions**: New members support outreach projects like the Computer Project and Children's Hospital STEM workshops.
- **Skill Development**: Established a pathway to build expertise in technical design and fabrication

## Gearheads Organizational Structure

Over **six years in FTC**, we have refined our structure, creating **organizational sub-teams** aligned with members' interests, goals, expertise, and willingness to learn.

**What We Do:**
- Sub-team-based organization that splits up tasks
- Assigned Leaders with dedicated action items
- Efficient organization

**How we Do it:**
- **2-week, rigorous** Agile SPRINTs
- Weekly debriefs of completed tasks
- **SPRINT** leaders responsible for delegating tasks

**Why we do it:**
- To ensure efficient team performance
- To minimize Vertical Conflict among sub-teams
- Be 100% ready for competitions

## Developing our team's plans

Our team's plans integrate individual member goals to drive growth and success.

- **Season Kickoff**: We start by identifying individual goals based on learning areas
- **Subsystem Integration**: Goals are mapped to focus teams, then applied team-wide.
- **Example**: Aryav aimed to enhance technical skills → The team adopted a goal to create judging models of our innovative elements.

| Team Member Name | List 3 Learning or Skill Growth Goals for the Year |
|---|---|
| Avaneesh Muralidharan | Be more involved with advocacy efforts, enrich and improve team documentation by setting up a format for next year's kids to follow, finally keep pushing to learn more CNC skills |
| Matthew Nustad | 1. Make more detailed, accurate MGD sprint plans 2. Get the non-senior members ready for next year 3. Expand our production hub efforts a lot, with new structure from SBoD 4. Make more unique youtube content |
| Misha Maheshwari | Want to contribute more to mechanical, expand the CHW outreach project, get more involved in scouting/ connecting with other teams, start being more active and intresting on instagram, be able to have a basic knowleedge of software, robot parts, design, and outreach |
| Josef Keup | |
| Sid Rane | Game strategy, finalize structure for school district sustainability, grow FLL program. |
| Yuva Sharma | Become a better contributor to robot deseighn and geain better CAD skills as well as expand the CAD outreach program |
| Thomas Winn | Become a larger contributor towards the assembly of the robot, gain an even better understanding of CAD (mainly with onshape), further understand how the robot is wired and how the rev hubs communicate with motors, servos, and sensors. |
| [illegible] | Expanding the Childrens Hospital Project(more hospitals), grow my software skills, be able to contribute in SW, and help |

# Engineering Design Process

*THINKing outside the box*

## Cost/Benefit Trade Off Analysis

| Mission - Tele-Op | Points Earned | Difficulty (1-3) | Grade (A-C) |
|---|---|---|---|
| PARK OBSERVATION ZONE | 3 | 1 | C+ |
| NET ZONE | 2 | 1 | C |
| LOW BASKET | 4 | 1 | C+ |
| HIGH BASKET | 8 | 2 | A |

- Early-Stage planning with a **Game-Points Matrix**
- Grading "missions" by **risk/reward**
- Identifying Key game components for **maximum points**
- Developing **robot subsystems** by identifying capabilities

## Monte Carlo Performance Simulation


- **Custom simulation designed on Excel** used extensively during testing
- Predicting game performance with **extensive game data**
- Using data like mission times and produced scores **to make strategy and design decisions easily**

## Industry-based Engineering Process - DHF

**Step 1: Game Point Matrix** - Points possible in TeleOp and Autonomous

**Step 2: Define Robot Capabilities** - What are our goals and what does the robot need to do on the field

**Step 3: Brainstorm Failure Modes** - Brainstorming ideas to minimize errors in matches

**Step 4: Analysis** - Maximizing the best output of points by using the Monte Carlo simulation

**Step 5: Design with CAD** - CAD subsystems based off of the requirements

**Step 6: Build Subsystems** - By using custom fabrication tools

**Step 7: Integrate** - Assembling the robot perfecting each subsystem before integration

**Step 8: Test and Optimize** - Test the robot on the field and optimize

### GE Healthcare's DHF Engineering Process

- Professional engineering **design history file (DHF) framework** from GE Healthcare
- Same engineering rigor medical product development like MRI, CT, XRay
- **Subsystem based design** & prototyping for efficiency and reliability
- Disciplined rigorous **2-week sprint plans**, through the 8-month season.

### Rigorous Engineering Discipline

- **Game points matrix** – to analyze the risks and rewards of each opmode.
- **User and subsystem requirements** – to design the subsystems and integrations
- **FMEA (Failure Mode Effect Analysis)** – identify, observe any failure modes in the design and take **corrective actions to address the failure modes**.
- **Monte Carlo Simulations** to predict our range of scores & mission times.

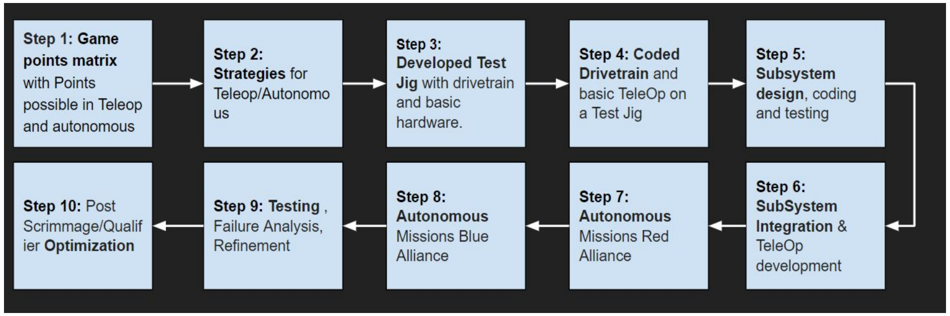
### Later phases of the process- Robot Design, Fabrication, Integration

- **Custom Robot designed with CAD - OnShape and** Fabricated components using **3D printing, CNC milling**, and **sheet metal** manufacturing
- Subsystems based design. Extensive testing at scrimmages and qualifiers
- **Optimized performance** based on test results

# Software Design Process

*THINKing the best*

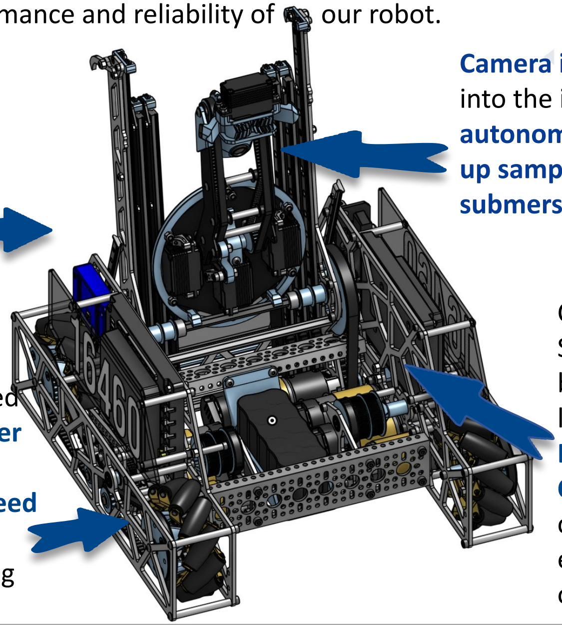
## Software Design Highlights




- Disciplined **subsystem & Design History File** based development process
- **Driver centric dual FOV** (in the drivetrain and intake) control that leveraged trigonometry
- **Optical odometry** using Roadrunner with autocorrection
- Complex **PID + Motion Profiling** for Differential control
- **4 button** sophisticated **state machine design**
- **Camera** based **autonomous sample identification** and pick up.

## Failure Mode Effect Analysis (FMEA)

We analyzed design **failure modes** & added effective **mitigations** to improve performance and reliability of our robot.



Manual override and **State machine control**

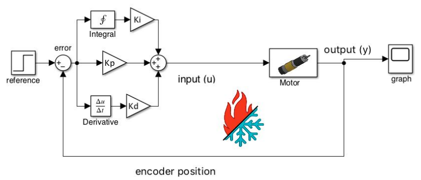
**Optical Odometry** based drivetrain, **Driver centric** (FOV) driving, and **speed damper** to prevent toppling

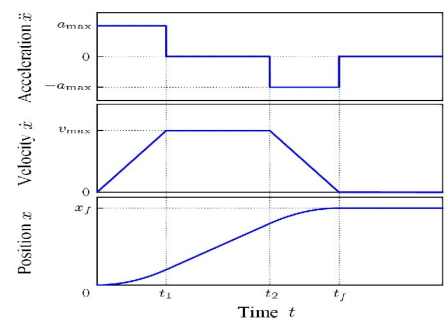
**Camera integrated** into the intake to **autonomously pick up samples from the submersible**

Control System based PIDF lift control, **Driver Centric (FOV)** control for easy orientation

## Complementary Mechanical & Software Control

- The robot consists of **five subsystems**: Intake, Claw, Elevator, Drivetrain, and Ascent.
- A **state machine** coordinates the **Intake, Claw, and Elevator** for precise sample pickup and delivery.
- **Software and mechanical design** function seamlessly to optimize robot performance.
- The **state machine-controlled and FOV integrated claw** ensure precise and consistent sample pickup.



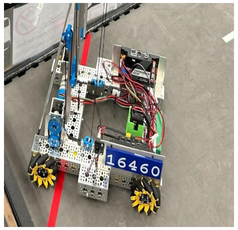




- **Camera based sample detection** and pickup in Autonomous mode. **Autonomous specimen delivery** during TeleOp mode for accuracy and reliability.

# Design Iterations

*DESIGNing the best*

## Mark 1 Robot



**Game Capabilities**
- Pick up samples using an **external claw**
- Raise samples using **previous season's arm**
- **Drive quickly** on field

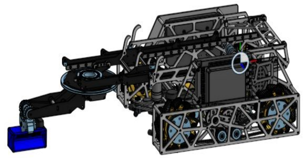
**SW Capabilities**
- State machine implementation
- Road Runner implementation

**SW FMEA Error Reduction**
- N/A as this was a 30-hour baseline robot

**HW Capabilities**
- Basic drive train
- Differential belt drive with GoBilda slides
- Servo driven claw

**HW FMEA Error Reduction**
- N/A- this was a baseline robot

## Mark 2 Robot



**New Capabilities**
- **Level 2 Ascent**
- Autonomous Pathing
- High/low rung
- **6 degrees of freedom**

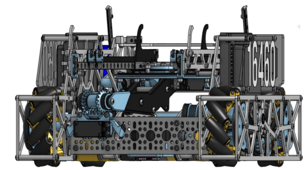
**SW Improvements**
- PID Controllers
- Motion Profiling
- Driver FOV
- Optical Odometry

**SW FMEA Error Reduction**
- Optical Odometry
- PIDF / Motion Profiling on Arm
- Driver FOV

**HW Improvements**
- Elevator: Diff. drive, carbon fiber
- Lift: $2^{nd}$ level PTO with 6-motor lift
- Claw: Micro servo driven, quicker

**HW FMEA Error Reduction**
- Smaller frame/claw
- Secure pickups

## Mark 3 Robot



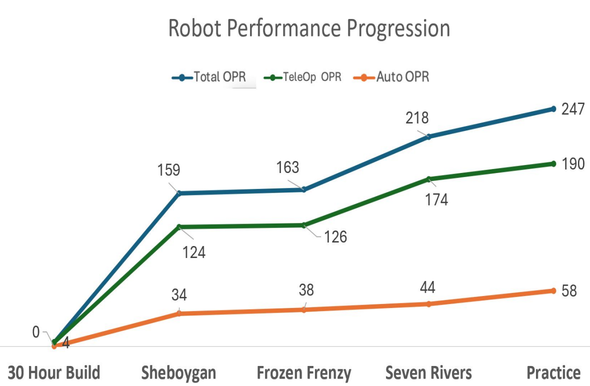
**New Capabilities**
- Tele Op **Specimen Drop Automation**
- Reliable Auto **Level 3 Ascent**
- **New claw** for reliability

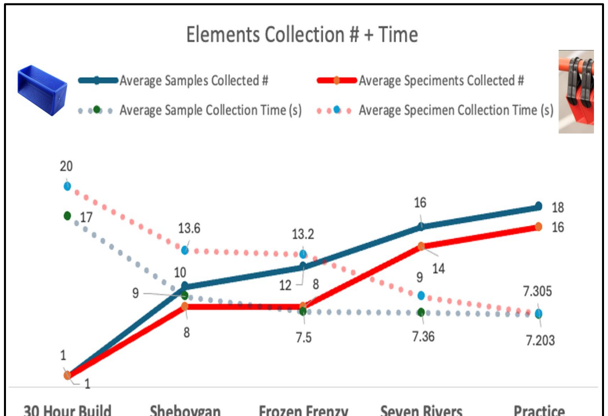
**SW Improvements**
- Specimen macro
- Camera in Auto
- Better auto paths

**SW FMEA Error Reduction**
- State machine sequence adjusted
- Auto pick position
- Specimen delivery
- Claw FOV

**HW Improvements**
- Lift: added bottom foot
- Claw: Larger servo

**HW FMEA Error Reduction**
- Specimen delivery consistency
- Claw grabbing consistency
- Active Intake Jam




**How do we Iterate so quickly?:**
- Iterated based on **past designs, strategies and driver experience**
- **Continuously refined** robot design and strategies..Monte-Carlo analysis
- Mark 3 features a **$3^{rd}$ level hang** and **brand-new claw** to score more points in a more reliable manner
- **Fully 3D modeled in OnShape** and built in weeks
- Software developed using **subsystem-based design** in under two weeks

# Mechanical Design & Fabrication

*DESIGNing the best*

INTO THE DEEP PRESENTED BY RTX | FIRST TECH CHALLENGE

## Mechanical Design

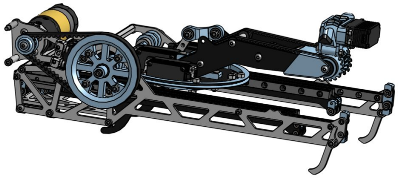
We believe strong game performance stems from **efficient, thorough planning** early in design cycle. To achieve this, we implemented **industrial design strategies** throughout our build process.

1. **Goal-Oriented Design**: Define robot and subsystem capabilities based on end goals.
2. **Advanced CAD Planning**: Pre-plan each subsystem before integration.
3. **Precision Fabrication**: Use advanced techniques for a sleek, high-performance robot.

## 100% CAD Based Design

We used **OnShape Software to CAD design our whole robot** in the first few weeks after kickoff. Using CAD allowed us to create custom parts using methods like **3D printing or CNC machining**, giving much more design flexibility than a solely kit-based approach.

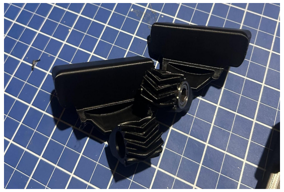
- Organized our **CAD design into subsystems** and defined part movements using joints
- Confirmed the **design could meet all planned objectives** and ensured moving parts had enough space
- Used joints to effectively experiment with **complex features like linkages**
- A **100% CADded design** enables us to employ more custom fabrication methods outlined on this page

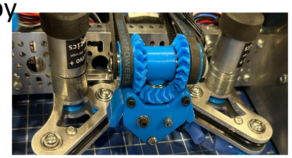


onshape

## 3D Printing

- **Precision Manufacturing**: Used **3D printing** for complex, multi-featured parts.
- **Advanced Tools**: Leveraged the **Bambu Lab 3D printer** for strong, high-accuracy components impossible to fabricate by hand.
- **Rapid Prototyping**: Accelerated development by quickly producing parts.
- **Iterative Design**: Applied 3D printing in intake mechanism development, enabling **rapid iterations** and keeping us on schedule.





## Our CNC Milling Capabilities

We utilize **CNC milling for both 2D and 3D parts**, seamlessly integrating with our fully CAD-designed robot. Three working mills:

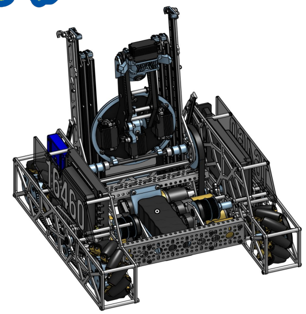
- **MP (Mostly Printed) CNC**: Custom-built for large parts like side plates and technical demonstrations.
- **6X6 Industrial Mill**: Ideal for small, intricate parts like brackets and gears.
- **Large-Scale "PrintNC" Mill**: Enables high-precision machining for robust components.

### Advancing Technical Capabilities

- Expanded skills and capabilities enabled **record-fast** robot fabrication and assembly in **2 weeks**.
- Undertook **two major projects**: the **DIY CNC** project and **Production Hub** initiative.
- Gained expertise in **carbon fiber fabrication**.

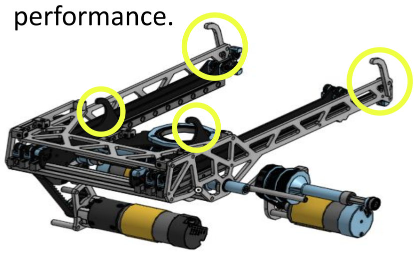
# Our Current GEarbot

***DESIGN**ing the best*

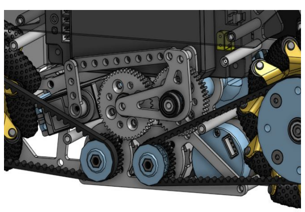


## Hanging Mechanism

- **Custom-built transmission** for efficient power transfer.
- **Drive motor-powered ascent**, generating torque to lift the robot to all **three levels**.
- **Compact design** ensures minimal space usage without sacrificing performance.

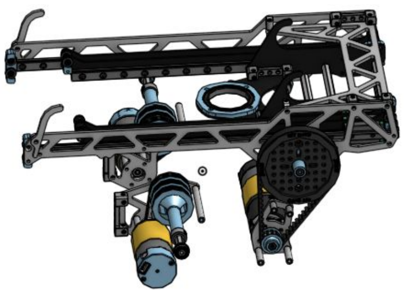


**A Servo-mounted gear activates the PTO**



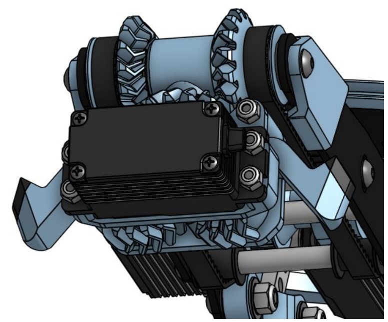
## Elevator Subsystem

- Operated with a Differential drive
- Control both the **vertical and rotational with just** two motors
- **Keeps the center of mass low** with strategic motor placement
- Both **vertical and horizontal extension possible through a central, rotating axle**
- The slides from the lift **double as the ascent mechanism as well**



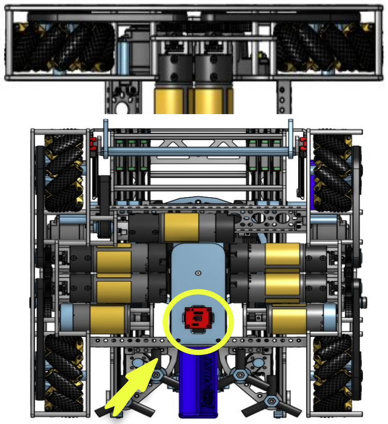
- Easy driver control of **rotational and vertical** motion of the arm
- **6 degrees of freedom** produced through dual-differentials
- Carbon fiber plates increase stiffness and minimize weight

## Intake Subsystem



- **Contoured geometry** fits sample surfaces perfectly
- **Servo-Operated pinchers** grab samples from the outside, enabling secure pickup
- **Six degrees of freedom** enable pickup from any random orientation.
- **State machine & FOV** reduce driver effort.
- **Tight, efficient pickups** through software and hardware design
- **Camera Integration** to enable submersible pickups in autonomous

## Drivetrain



- **Compact chassis** with belt-driven mecanum wheels for functionality.
- **Low drive motors** lowers center of gravity, boosting stability.
- **Optical odometry** enables precise autonomous navigation.
- **FOV software** orients the robot to the driver's view for easier control. **Dual FOV for both drivers**.
- **Optical odometry** improves autonomous accuracy by reducing slippage and enabling error correction.

# Innovation in Robotics

*INNOVATing to maximize performance with minimal hardware*

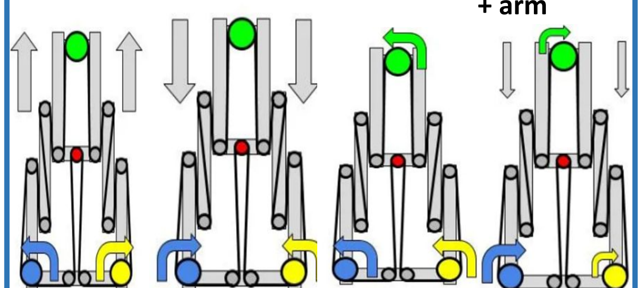
## Differential Lift & Arm

- **Minimized driving and operation** to reduce movement between scoring samples and specimens
- Implemented an innovative **differential mechanism** using **two motors** for both **vertical lift** and **rotational deposit arm**
- Positioned motors at the base to **lower the center of gravity**
- **Mechanism translates motor velocities:** (v1 + v2) → Vertical motion & (v1 - v2) → Rotational motion
- Achieved fine control over the end effector's position while minimizing wiring and servo use
- Integrated a **3-degree-of-freedom** arm for an efficient scoring mechanism

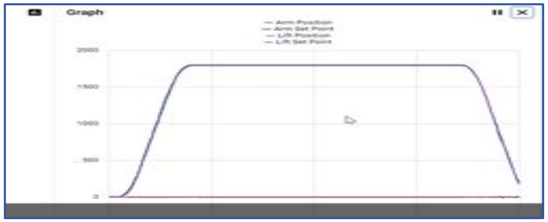
## Differential Mechanical Design

- **Differential design operates on opposing forces:** (1) Motors moving in the same direction → **Lift moves up or down** (2) Motors moving in opposite directions → **Lift forces cancel, causing arm rotation.**
- **Custom belt-driven linear slides** enable **smooth torque transfer** between the lift and arm . **Three main functional elements:** (1) **Extending lift** for vertical motion (2) **Rotating arm** for precise positioning (3) **Claw** for controlled manipulation
- **Linear bearing rails and blocks** provide stable and precise lift extension
- **Turret mechanism** delivers industrial-grade rotational precision. **Differential mechanism** on the claw allows multi-directional rotation, enabling **6 degrees of freedom** across the **lift, arm, and claw**

| Motors in opposite direction = lift up/down | Motors in same direction = arm movement | Motors in differential speed = lift + arm |
|---|---|---|



```
double t1 = liftDeltaT;
double t2 = armDeltaT;
double f1 = 0;
double f2 = 0;
if (t1 != 0) {
    f1 = min(1, 1 / (t2 * armMaxPower / t1 + liftMaxPower));
}
if (t2 != 0) {
    f2 = min(1, 1 / (t1 * liftMaxPower / t2 + armMaxPower));
}
```




## Differential Controls

- **Sophisticated controls and tuning** are required to maximize the differential mechanism's potential.
- **Custom dual PIDF controller** (Proportional, Integral, Derivative & Feedforward) and **trapezoidal motion profile** optimize motion.
- **Power-sharing scheme** enables simultaneous movement of the lift and arm for **fastest combined motion.**
- **Empirically determined maximum speed and power** for individual lift and arm operations.
- **Refined PIDF tuning procedures** ensure precise and efficient movement.
- **Motion synchronization factors** are calculated to ensure simultaneous stopping without exceeding motor power limits.

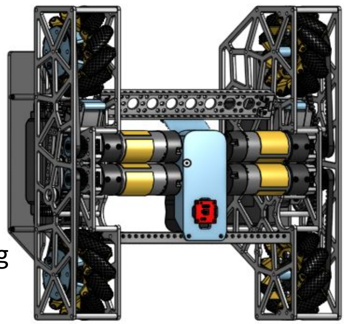
# Control Award Submission

*CONTROLling with efficiency*

## Control Sensors

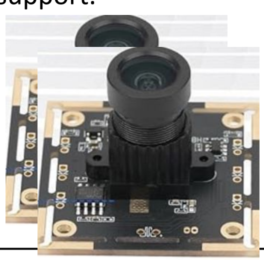
### Optical Odometry

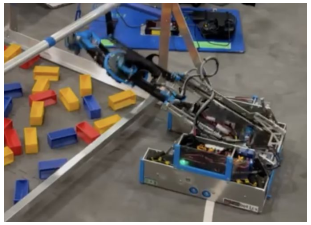
- **Optical odometry sensors** replace conventional wheels for precise robot localization during autonomous mode.
- These **compact sensors track surface patterns**, providing high-resolution data on linear and rotational motion.
- **Improves navigation accuracy** by reducing dependence on wheel encoders.
- **Enhances autonomous performance** by offering reliable feedback, even on surfaces prone to wheel slippage.

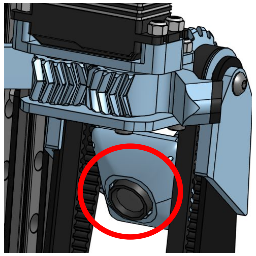


### Camera based Sample autonomous pickup

- **Camera based sample pick:** Open CV and Camera based sample detection and pickup for bucket . On Bucket side we can do 4 + 4 samples total to a 56 point auto.
- **Autonomous mode in TeleOp**: We have autonomous driving support in TeleOP mode to deliver 11 specimens in TeleOp mode with autonomous support.



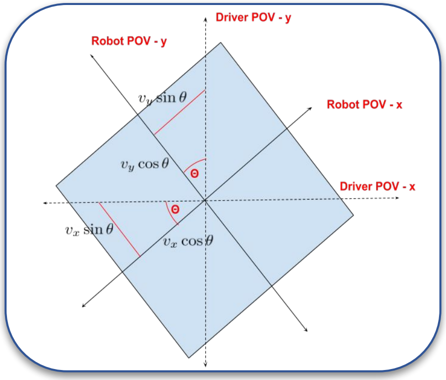




## Driver Control Enhancements

### Driver Centric Driving

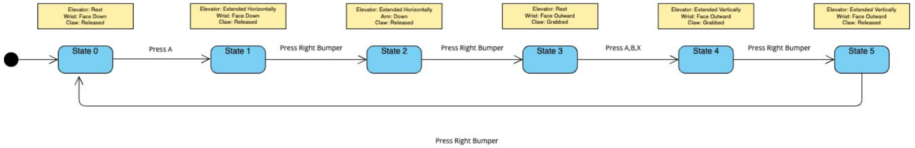
- **Trigonometry-based TeleOp control** keeps movement aligned with the driver's view.
- **Robot moves relative to the driver**, regardless of field orientation.
- **Simplifies driving and reduces workload**, enhancing maneuverability.
- **Improves precision and responsiveness** for efficient control.




```
sidePower = tempForwardPower * Math.cos(angle) + tempSidePower * Math.sin(angle);
forwardPower =-tempForwardPower * Math.sin(angle) + tempSidePower * Math.cos(angle);
```

### State Machine

- **State machine enables four-button TeleOp control** for seamless sample handling.
- **Automates pickup, deposit, and reset**, simplifying operations.
- **Supports single and dual-driver modes**, reducing complexity.
- **Enhances efficiency and minimizes driver workload**.



# Mathematics in our Robot

*INNOVATing to push the envelope*

## Field-Centric Driving Trigonometry

- **TeleOp driving is configured to the driver's perspective**, ensuring movement is independent of robot orientation.
- **Trigonometry-based control converts robot coordinates to field coordinates**, simplifying maneuverability.
- **Uses gamepad inputs (tempForwardPower, tempSidePower) and gyroscopic angle** to compute movement.
- **Enhances driver control and responsiveness**, reducing complexity in navigation.

**sidePower** = tempForwardPower * Math.cos(angle) + tempSidePower * Math.sin(angle);

**forwardPower** = -tempForwardPower * Math.sin(angle) + tempSidePower * Math.cos(angle);

## PIDF Control & Motion Profiling

- **Custom PIDF controller** provides flexibility beyond open-source solutions, ensuring **precise motor control and stability**.
- **Features include a customizable feedforward function** based on position, velocity, and acceleration, **enhancing responsiveness and efficiency**.
- **Integral reset prevents windup**, improving **control accuracy and system reliability**.
- **Trapezoidal motion profiling** optimizes lift movement by limiting velocity and acceleration, **ensuring smooth and controlled transitions**.
- **Custom motion profiling enables chainable profiles and timed movements**, allowing **seamless automation, reduced jerk, and improved repeatability**.

**PIDF Response Function**

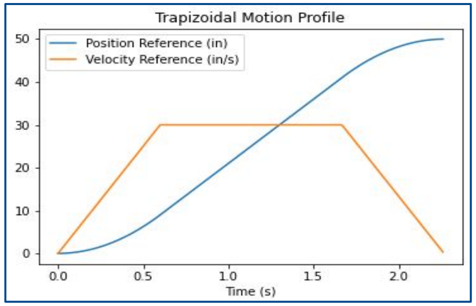
$$F(t) = K_p \cdot e(t) + K_i \cdot \int_0^t e(t)dt + K_d \cdot \frac{de}{dt} + K_f(x(t), v(t), a(t))$$

$$e(t) = x(t) - x_{\text{actual}}(t)$$

**Example Feedforward Function**

$$K_f = K_g + K_x \cdot x(t) + K_v \cdot v(t) + K_a \cdot a(t)$$

```
public double getX(double t) {
    if (t < ti) {
        return xi + vi * (t - ti);
    }
    if (t < tf) {
        if (xf > xi && flat) {
            if (t < ti + (vm - vi) / am) {
                return xi + vi * (t - ti) + am * Math.pow(t - ti, 2) / 2;
            } else if (t < tf - (vm - vi) / am) {
                return xi + vm * (t - ti) - Math.pow(vm - vi, 2) / (2 * am);
            } else {
                return xf - vf * (tf - t) - am * Math.pow(tf - t, 2) / 2;
            }
        }
    } else if (xf > xi) {
        if (t < (tf + ti) / 2 - vi / (2 * am)) {
            // Additional logic can be implemented here
        }
    }
    return 0;
}
```




**Acceleration Phase:**

- Increase velocity linearly from 0 to maximum.
- Position: $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$
- Velocity: $v(t) = v_0 + at$

**Cruise Phase:**

- Maintain constant velocity.
- Position: $x(t) = x_1 + v_{\max}(t - t_1)$
- Velocity: $v(t) = v_{\max}$

**Deceleration Phase:**

- Decrease velocity linearly to 0.
- Position: $x(t) = x_2 + v_{\max}(t - t_2) - \frac{1}{2}a(t - t_2)^2$
- Velocity: $v(t) = v_{\max} - a(t - t_2)$

# 33 New Industry Connections

*CONNECTing with our community*

INTO THE DEEP
PRESENTED BY RTX

FIRST TECH CHALLENGE

## Technical Connections

Jeff Fenstermaker | Wesley Bassindale | Rishi Rane | Timothy Nustad | Fernanda Lima | Ben Skeleton | Doug Miller | Robert Sinur

- **Technical connections** include experts from **GE Healthcare, Milliman, Milwaukee Tools, Elmbrook Schools, Generac, and more**.
- **Knowledge shared** through **meetings, webinars, tours, and coaching**.
- **Many connections** generously **sponsoring us for the 2024-2025 season**.
- Focusing on applying and sharing what we learn with the community

## FIRST Connections

Jane Blau | Judy Scaro | Tammy Baldwin | WI State govt. | Rob Hutton | Jennifer Black | Renee Blau

- Helped us expand **FIRST involvement** locally and nationally.
- Advocated for increased structured support for FIRST across the state
- **Connections include** the **Wisconsin FIRST President, State Senate members, and senior FLL, FTC, and FRC mentors**.
- **Guidance enabled** contributions to **FLL & FTC events**.
- **Helped us distribute computers** to coaches and teams for upcoming seasons.

## Outreach Project Connections

Leslie Scott | Akel Akel | Shalini Sharma | Trevor Carter | Deb Nustad

Christopher Dewall | Peter Haydock | Allison Conrad | Brett Gruetzmacher | Don Kurth

- **Company executives, physicians, hospital admins, and entrepreneurs**.
- **Supported** & expanded our **Hospital Outreach Project** to the VA
- **Backed computer outreach** for local and international teams.
- **Helped organize TWIST** to promote **STEM for girls** in October.
- **Advocating to expanding** DPI grant Funding **FIRST in Wisconsin**

Milliman | Johnson Controls | Children's Wisconsin | Milwaukee | GE Healthcare | Elmbrook Schools

### Tom Michalski

*Former Wisconsin State Assemblyman*

- **Hosted him** to discuss the **tech job market and local career programs**.
- **Promoted dual enrollment** at **WCTC and local colleges** to save students time and money.
- **Collaborating with Michalski & WCTC** to develop **FIRST-related certifications**.

# FIRST Ambassadors in the community

## *MOTIVAT*ing the FIRST community

FIRST TECH CHALLENGE

INTO THE DEEP

PRESENTED BY RTX

### Advocating for Structured FIRST support on a State and national level

- **Attended FIRST advocacy day** for two years in a row at the state capital, recognizing the need for robotics advocacy.
- **Advocating directly with Rep. Adam Neylon, Senator Hutton and other legislators** to **increase DPI Robotics League Funding** from **$1.5M to $4.5M.**
- **One of five teams** working with Student Association for STEM Advocacy to secure **Chi and Sciences Act grant funding** for robotics programs.
- **Expanding robotics education** to **public schools**, expanding education in **CAD, CNC, and important technology skills**

### FIRST Themed Little Libraries for March of Dimes

- **Partnered with March of Dimes**, a national nonprofit for babies' health.
- **Rookie member Roman led the project** from start to finish.
- The Libraries we built auctioned for **$2,600 each, raising $5,200**
- **Expanded GEarheads and FIRST awareness** to a new community.


### Participating at community Maker Faires

- **Invited back for the 3rd year** to the two-day Milwaukee Maker Faire at Discovery World (Nov 2-3), **hosting 500+ makers and engineers**
- Showcased the **FIRST message and our fabrication capabilities**
- Displayed and demonstrate our **MPCNC and share resources to** build your own.
- Engaged many interested in **joining FIRST programs.**

### Spreading FIRST within our school and district

Elmbrook Schools
become what's next

- **Worked with our school district** to fund robotics teams and cover **FLL & FTC registration and field costs**.
- **Collaborated with district superintendent, principal, and athletic director** to secure funding and support, increasing school robotics spaces and covering registration and baseline fees

### Supporting the FIRST mission at TWIST

- TWIST (Together, Women in STEM Thrive) is an event promoting an environment for **girls to advance their skills**
- Our team ran a booth **representing FTC teams** and showcased our robot
- We proudly staffed with **an all-girls team**

# Impacting the FIRST Community

*Connecting with our peers in FIRST and STEM*

INTO THE DEEP
PRESENTED BY RTX

FIRST TECH CHALLENGE

## Hosting Rookie Team Development Events

**200+ Hours Invested**

**21 FTC Teams Impacted**

**GEarheads** just completed hosting our first **Qualifer**! – with 21 rookie teams attending, nearly **300 students**, and 70+ volunteers.

We supported our rookie teams with:

- **5-week webinar series** with online resources to get ready
- On site **technical support**
- **Extra tournament FTAs**
- Lunch-time demos on **CAD and CNC**
- 4 new **FTC Judges joining FIRST Wisconsin**

## Developing the FIRST WI Production Hub

**8 Projects Completed, 29 Parts for FLL and FTC Teams**

**4 Teams Impacted**

- With the support of our technical mentors, our team achieved our **highest-ever custom fabrication capability.**
- When the FIRST student board of directors launched the **Production Hub initiative**, we joined as **one of their first official FTC teams.**
- We have completed **8 projects so far for one FLL team and 3 FTC teams.**
- **Connecting teams to tools like CNC, laser cutting, and 3D printing**

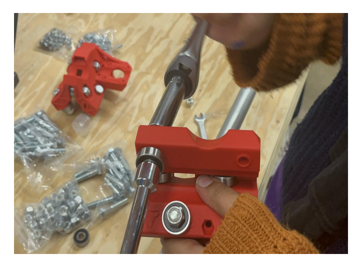
PRODUCTION HUB PROGRAM

## DIY MPCNC Project

**70+ Hours Invested**

**3 Teams Impacted**

- Grew our "DIY CNC" project to help **rookie teams build a CNC**.
- Utilized the **"MP (mostly printed) CNC"** design, supplying all parts and **guiding teams through each step.**
- Launched at a rookie qualifier and are piloting builds with three teams: **17347 Redcat Robotics, 12966 C-Gull Robotics, and an FTC team from North Carolina,**
- **Improving our documentation to make the designs more accessible**



# Closing the Digital Divide for 1000+

## *Connect*ing with our local community

FIRST TECH CHALLENGE
INTO THE DEEP
tech lit Africa
FIRST

| 2021 - The initiation | 2022 – expanding to WI | 2023 – expanding nationally | 2024 – expanding to corporate connections |
|---|---|---|---|
| *9 laptops donated □ 90 students impacted* (Elmbrook Schools) | *16 laptops donated □ 160 students impacted. Spread via corporate connections* (Milliman) | *35 laptops donated --> 350 students impacted. Spread via our outreach connections* | *44 laptops donated □ 440 students impacted. Merging our outreach projects with Tech Lit Africa and FIRST WI* |

## Why

•**Problem Statement:** Many talented students in underprivileged Milwaukee school districts face **barriers to accessing FIRST/STEM due to a lack of basic resources like computers**.

•**Solution:** Our primary focus is **bridging the digital divide by providing access to computers**. We have **collected, refurbished, and donated 44 computers this season**, adding to the **60 computers distributed in previous seasons** to FIRST teams and local STEM organizations.

## Connections Made & Our Process

•Organized **computer collection drives** in partnership with **school districts and libraries**.

•Partnered with our **school district's IT team** to gain the necessary technical skills for refurbishing devices.

•**Secured low-cost, authorized Microsoft software licenses** through Blair Tech (a Microsoft Authorized Refurbisher).

## Planning & Learning

•Conducted **multiple computer collection drives** and established **relationships with local companies** for donated devices.

•**Inventoried and tracked** all devices through a **detailed refurbishment process** for repair, recycling, or resale.

•**Refurbished computers responsibly**, ensuring data security, fixing hardware issues, and installing new operating systems.

## Our Impact

•**Expanded from local Milwaukee efforts to an international initiative**, providing **tech access to hundreds of students annually**.

•**44 laptops distributed this season**, in addition to **60 from prior seasons**.

•**4-Year Program Impact – Devices Distributed:**

| | |
|---|---|
| **19** | to **FLL teams** |
| **45** | to **FTC teams** |
| **5** | to **STEAM Milwaukee for classroom Learning Labs** |
| **5** | to **República School in Honduras** |
| **5** | to **Tech-Lit Africa in Kenya** |
| **13** | to **SEA-Literacy Asian refugee families** |
| **5** | to a **STEM program at St. Mary's School** |
| **7** | facilitated from corporate donor directly to **Cyber Security High School Program** |

•Strengthened impact through **Tech Lit Africa**, a **Kenyan non-profit dedicated to providing technology access to underprivileged students**.

•**Laptops donated to FIRST Wisconsin** (Renee Becker-Blau)

# Spreading FIRST & STEM to the Children's Hospital

***Connect*ing with our local community**

| 4 bi-monthly sessions at the Hospital □ 50 students impacted | 5 bi-monthly sessions at the Hospital □ 60 students impacted | 5 sessions at the Hospital + 1 session at the VA □ 50 students + 6 veterans impacted |
|---|---|---|
| *2022 – The birth of the hospital project* | *2023 – more focused integration of FIRST* | *2024 – expanding into the Veterans Association* |

## Hospital Outreach Project

**The hospital outreach project has been one of the most meaningful projects we have ever done.**

**Problem Statement:**

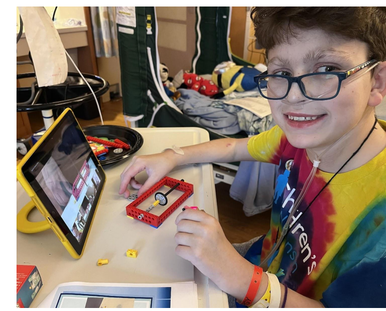
- Brookfield kids enjoy **many STEAM and FIRST opportunities.**
- Kids battling cancer, often in hospitals, miss out on these experiences.
- Recognized benefits of **"play therapy" inspired us to bring STEAM and FIRST to these children.**

**Solution:**

- Offer **STEAM and FIRST sessions** where kids build and interact with robotics kits.
- Use E-Blox Lights N' Motion kits for the first session.
- Teach kids how the kits work, **sparking potential new interests.**
- **Leverage research** showing that robotics/STEAM during treatment can improve overall well-being.

## Our Impact

- Connected with professionals, physicians and Child-Life Specialists at **Children's Hospital of Wisconsin** to create our session structure and introduce them to FIRST
- **5 sessions this year** (bringing our total to 15 in person and virtual), impacting close to 50 students this season - introducing kids and their parents to STEM & FIRST
- **Only team to be invited back** by Children's Hospital to host STEM-related sessions
- Continuing **ongoing bi-monthly sessions** with the Hospital



## Expansion To the Veterans Association Hospital

- At the suggestion of specialists, **we are planning a STEM Fair for Childhood Illness Survivors**, expanding to outpatient events as well
- Now demonstrating **FTC robots at sessions** for the kids to interact with
- Expanded our work with the Children's Hospital with the the **Veterans Association**
- Hosted an **in-person session** with the VA, giving them a chance to work with FLL kits to have fun
- **The team at the VA have invited us to work with them to generate a proposal for expanding this!**