# Tips & Tricks to help Improve Reliability & Performance of your Robot & Team

Presentor Michael Leicht

# Who Am I?

- Manufacturing Engineer at Repligen
- FIRST Alumni (2004-2007) Team 303
  - FIRST Scholarship Winner (Apply Apply)
- B.S. Mechanical Engineer in 2011
- FIRST Mentor (2008 - Current)
  - Team 42, 2342, 1403
- 2022 Woodie Flower Final Award winner at FMA DCMP


# Overview

- Logistics
- FRC Games
- Robot Design
- Driver Practice
- Competition

# Logistics

- “FIRST is a Logistics Competition” Scott Meredith
- Harsh Truth - You can’t do this alone
- If you want to do better at FIRST, figure out your systems and processes
- Is everyone on the same page?
  - Do you have passengers on your team?
- Rookies: Enjoy your season & the process
  - Hot Take: Ask for help early

# Logistics

- Three Areas to improve
  - Money
  - Resources
  - Time
- Money
  - Fundraising
- Resources
  - Mentors
  - Shop/Equipment
- Time- We all have the same time

Katie Widen, 2020

| Need \ Have | Time | Money | Equipment | Experience | Network | Knowledge |
|---|---|---|---|---|---|---|
| **Time** | - | Buy it | Hack it | Use outside time | Ask for Help | Reduce Scope |
| **Money** | Make It | - | Build it | Re-use old stock | Ask for Help | Meticulous Planning |
| **Equipment** | Modified Processes | Outsource, buy parts | - | Redesign for your tools | Ask for Help | Find alternative, creative solutions |
| **Experience** | Research & Prototype | Buy lots of parts/stock for prototypes | Built it many times | - | Ask for Help | Reduce Scope |
| **Network** | Prototype Everything | Utilize customer support | Build lots of Prototypes | Internal Design Reviews | - | Explore past solutions |
| **Knowledge** | Research & Prototype | Acquire team sub-assemblies | Iterate on projects | Off-season projects | Ask for feedback | - |

# Logistics - Time

- “I keep looking at my students and thinking man we are wasting time” R.C. (1323)

- What wastes time during meetings?
  - Looking for tools and components
  - CAD files are broken, someone has them open

- What have you done during the preseason to to reduce wasting time for the upcoming season?

- How organized is your shop or meeting area?

# Logistics - Organizing

- How does 1678 organize their shop?
- 5S workplace organization method
  - Sort
  - Set in Order
  - Shine
  - Standardize
  - Sustain
- Do your tools have a set location or are they thrown in a drawn

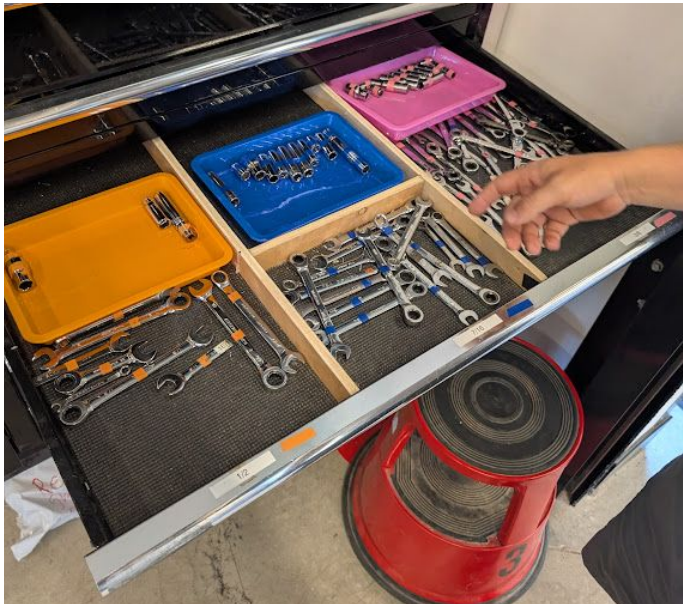

# Logistics - Organizing

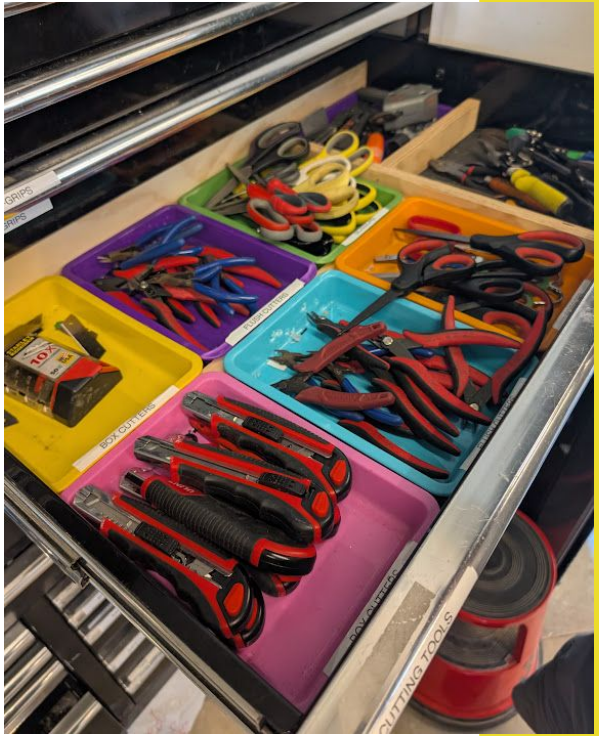
- How does 1678 organize their shop?



# Logistics - Organizing

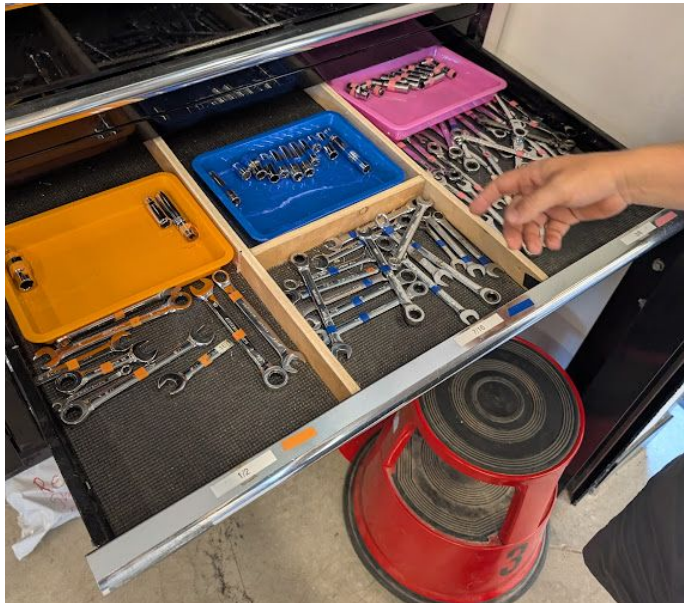
- Organizing Your Tools & Material

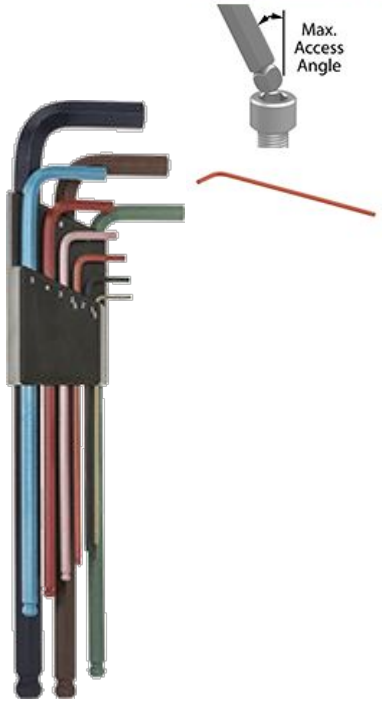




# Logistics - Organizing

- Color Code your tools (Label them as well)
  - Allen Keys






## Color-Coded Easy-Align Ball-Tip L-Keys

engages the drive with less contact than a straight tip, so you can turn screws at an angle instead of head on. Ball tips are handy for corners and tightly-packed areas, however, they don't grip as tightly as straight tips and may strip the drive of the fastener if you crank them too hard.

| Drive Size | Length: Overall | Length: Long Leg | Length: Short Leg | Max. Access Angle | Color | | Each |
|---|---|---|---|---|---|---|---|
| **Hex** | | | | | | | |
| **Painted Steel** | | | | | | | |
| 0.050" | 2 7/8" | 2 7/8" | 9/16" | 25° | Red | 2617N11 | $2.48 |
| 1/16" | 3 1/8" | 3" | 9/16" | 25° | Yellow | 2617N12 | 2.48 |
| 5/64" | 3 3/8" | 3 3/16" | 5/8" | 25° | Black | 2617N13 | 2.48 |
| 3/32" | 3 1/2" | 3 7/16" | 11/16" | 25° | Dark Green | 2617N14 | 2.52 |
| 7/64" | 3 3/4" | 3 5/8" | 11/16" | 25° | Orange | 2617N15 | 2.91 |
| 1/8" | 4" | 3 7/8" | 3/4" | 25° | Pink | 2617N16 | 2.97 |
| 9/64" | 4 1/4" | 4" | 13/16" | 25° | Dark Blue | 2617N17 | 2.97 |
| 5/32" | 4 3/8" | 4 3/16" | 7/8" | 25° | Red | 2617N18 | 3.10 |
| 3/16" | 4 3/4" | 4 1/2" | 15/16" | 25° | Blue | 2617N19 | 3.60 |
| 7/32" | 5 1/8" | 5" | 1 1/16" | 25° | Dark Yellow | 2617N21 | 4.34 |
| 1/4" | 5 7/8" | 5 5/8" | 1 1/8" | 25° | Green | 2617N22 | 5.00 |
| 5/16" | 6 3/8" | 6" | 1 1/4" | 25° | Brown | 2617N23 | 7.99 |
| 3/8" | 7 1/4" | 6 7/8" | 1 3/8" | 25° | Dark Blue | 2617N24 | 11.07 |
| 1.5 mm | 3 5/8" | 3 1/2" | 9/16" | 25° | Yellow | 2617N25 | 2.48 |
| 2 mm | 4" | 4" | 5/8" | 25° | Black | 2617N26 | 2.48 |
| 2.5 mm | 4 1/2" | 4 7/16" | 11/16" | 25° | Orange | 2617N27 | 2.60 |
| 3 mm | 5 1/8" | 5" | 3/4" | 25° | Pink | 2617N28 | 2.91 |
| 4 mm | 5 3/4" | 5 5/8" | 7/8" | 25° | Red | 2617N29 | 3.11 |
| 5 mm | 6 1/2" | 6 5/16" | 1 1/16" | 25° | Blue | 2617N31 | 3.93 |
| 6 mm | 7 1/8" | 6 7/8" | 1 1/4" | 25° | Green | 2617N32 | 5.27 |
| 8 mm | 8 1/4" | 7 3/4" | 1 3/8" | 25° | Brown | 2617N33 | 8.43 |
| 10 mm | 9" | 8 1/2" | 1 9/16" | 25° | Dark Blue | 2617N34 | 12.34 |

# Game Tips

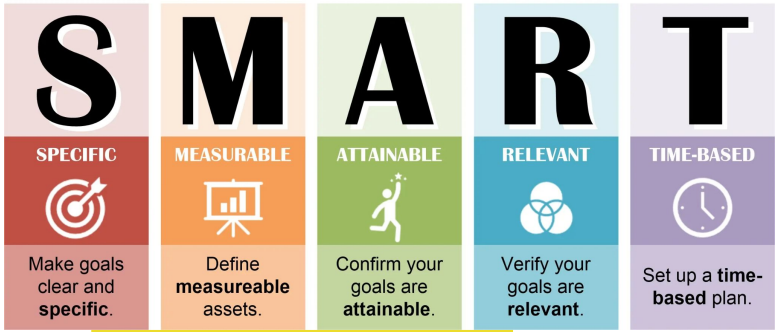
- Effective FIRST Strategies for Design & Competition. by Karthik

- ~~Read the Rules~~
- Comprehend the Rules (1678 Rule Quiz)

- Build a robot within your means

- Post COVID FRC Era- Elite Team are 13 + Cycles (full field cycles)

- SMART Goals
  - How many milliseconds does your elevator take get to L4? (500-750 ms)



# Robot Slides

- Design
- Mechanical
- Electrical
- Programming

# Design

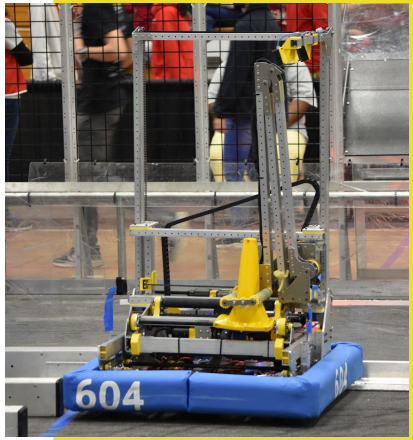
- Onshape (cloud based CAD)
  - Easier to review designs
  - CAD during snow days
  - Revision control
  - Know the software before the season

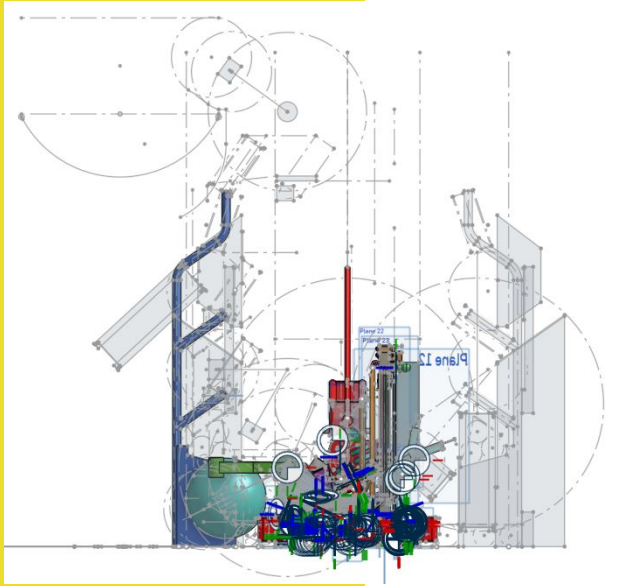
- FRCDesign.org
  - How to design FRC in the modern Era
  - Examples of FRC CAD

- Training - FRCDesign.org

# Design

- K.I.S.S.
  - Keep It Simple Silly
- Think about Degrees of Freedom (DOF)
  - You don’t need all of them (XYZ)
  - More systems more problems
- 2D/Layout Sketches
  - Define all your dimensions
  - The more details, the better
- Block CAD - For space/volume claims

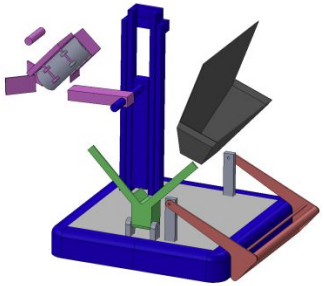


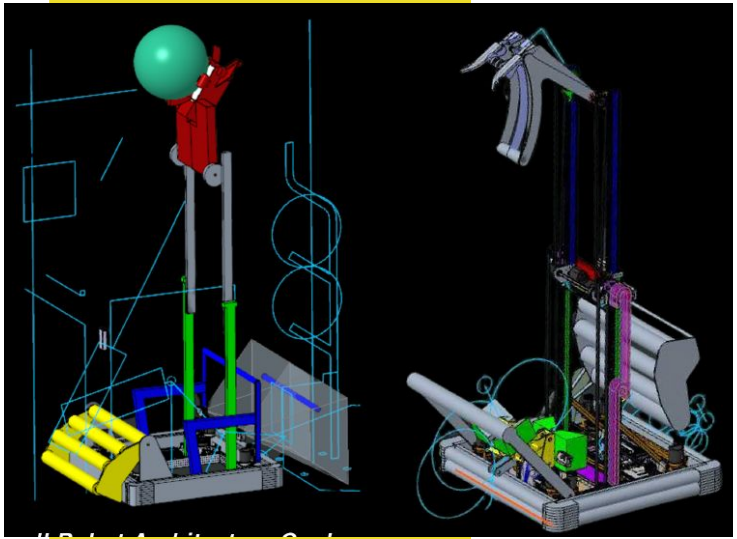
# Design- Block Cad

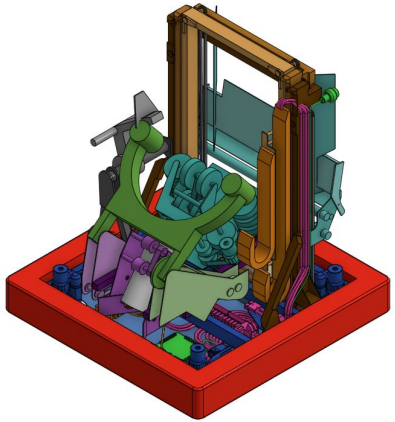
- 3005 High Fidelity Block CAD
- Mentors and students working on Block CAD.
- This method allows students to see the big picture.

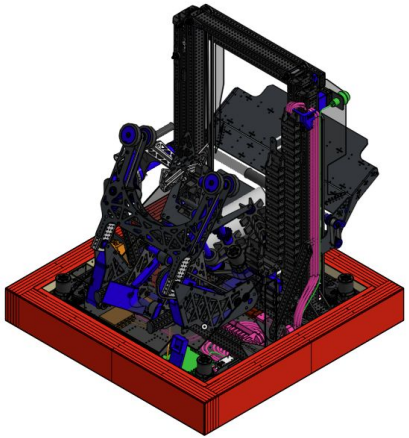
Dual Intakes flip-up to Laterator



Side Elevator with Intake, Funnel, Climber, and Wrist





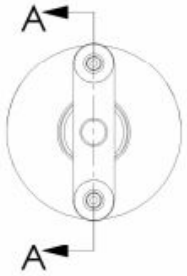


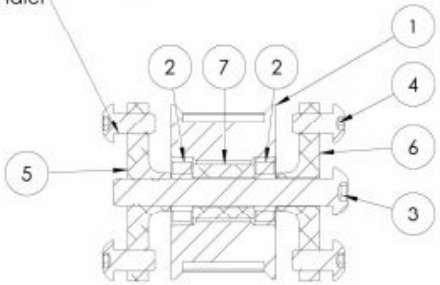
# Design- Drawing Control

- Working drawings
- Part Numbers
- Assembly drawings
- Printed on Drawings

| | PART NUMBER | DESCRIPTION | QTY. | Supplier |
|---|---|---|---|---|
| 1 | OPR25-P309 | 24 Teeth Timing Pulley, 5mm Pitch | 1 | 3DP |
| 2 | R4-2RS | 0.25 ID, 0.625 OD, 0.196 WD, Radial Sealed Ball Bearing | 2 | USA Bearings and Belts |
| 3 | 91255A545 | Alloy Steel Button Head Socket Cap Screw 1/4"-20 Thread, 2 Length | 1 | McMaster Carr |
| 4 | 91255A263 | Alloy Steel Button Head Socket Cap Screw #10-32 Thread, 0.375 Length | 4 | McMaster Carr |
| 5 | OPR25-P310 | Elevator Idler Block Tapped | 1 | CNC |
| 6 | OPR25-P311 | Elevator Idler Block Clearance | 1 | CNC |
| 7 | 92511A041 | Aluminum Unthreaded Spacer 0.5 OD, 0.5625 Length, 1/4 Screw Size | 1 | McMaster Carr |

Bolt Billet Spacers inside tube before inserting idler




SECTION A-A

AS SHOWN: 4 OPPOSITE:

| | |
|---|---|
| Material | ASSEMBLY |
| Finish | NO FINISH |
| Weight | 0.145 |
| Drawn by | BSP |
| Dimensions per | OPR25-A39.sldprt or .step |

| | |
|---|---|
| UNLESS OTHERWISE SPECIFIED | |
| PRIMARY UNITS | INCHES |
| NO BURRS OR SHARP EDGES | |
| TOLERANCES | |
| FRACTIONS | ±1/32" |
| 2 DECIMAL PLACES | ±.010" |
| 3 DECIMAL PLACES | ±.003" |
| FLAT PATTERNS | ±.005" |
| ANGULAR DEGREES | ±0.5° |
| BENDS | ±0.010" |

**OP Robotics** www.2056.ca

Large 2x2 Elevator Idler

DWG. NO. OPR25-A39

PRINTED ON 2025-01-24 | SCALE: 1:1 | SHEET 1 OF 1

**OP Robotics** www.2056.ca

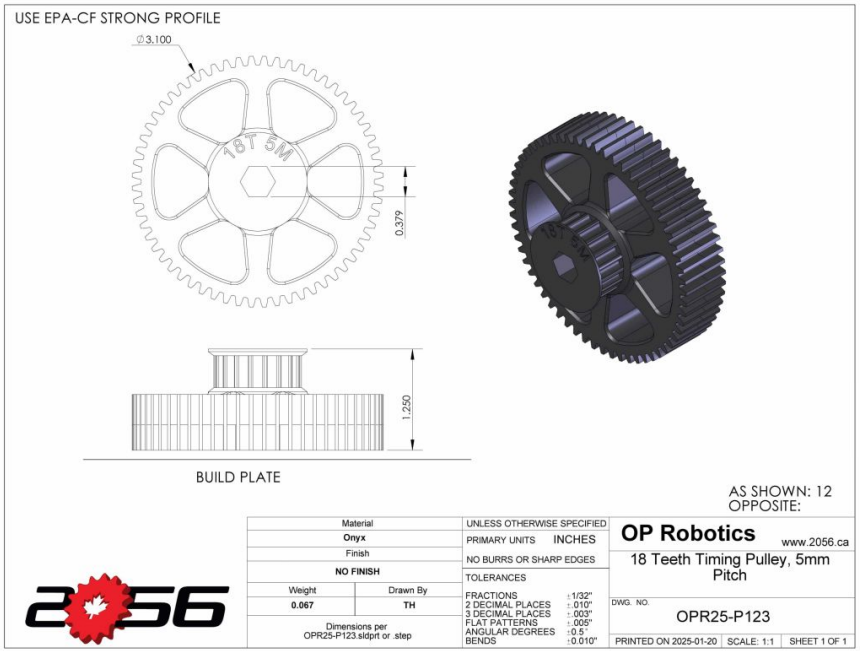
2x2 Plug Upright Bearing Block

DWG. NO. OPR25-A34

PRINTED ON 2025-01-26 | SCALE: 1:1 | SHEET 1 OF 1

# Design- 3D Printed Parts

- Emboss the part number on the print
- Combine parts (pulley & gear)
- Define how they want the part to be printed on the build plate
- Define the print profile for the slicer program
- 3D Printed Inserts to transmit torque
  - WCP
  - ThriftyBot

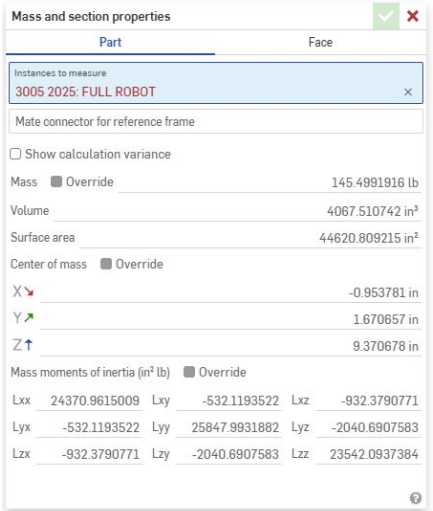


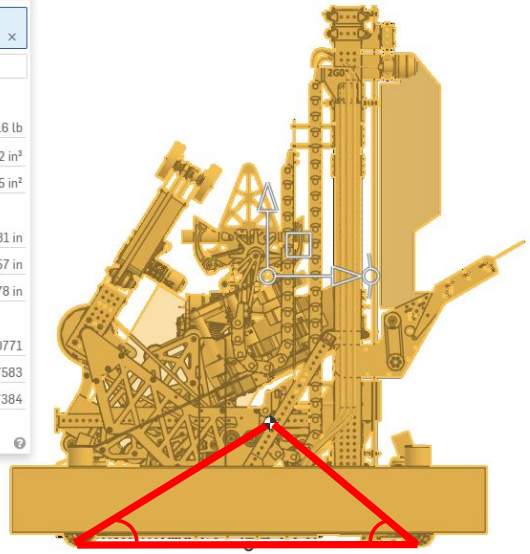
# Design and COTS

- Don’t reinvent the wheel
- COTS Supplies
  - West Coast Products (WCP)
  - Andymark
  - CTRE
  - REV Robotics
  - The Thirty Bot
  - Swerve Drive Specialties
  - SWYFT
- Knowing your supplies helps speed up design
- Order things early

# Design and COG

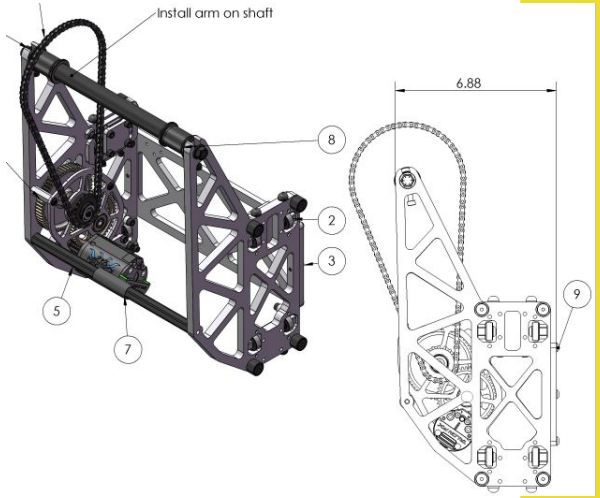
- Placement of your battery is not an afterthought
- Camera placement should be designed around
- Bumper attachment should be defined
  - Bumper Presentation by Chris Low
- 30 Degree Rule
  - Draw a triangle from your COG
  - Want to keep those angles under 30 degrees to prevent tipping
  - Check front/back & left/right directions

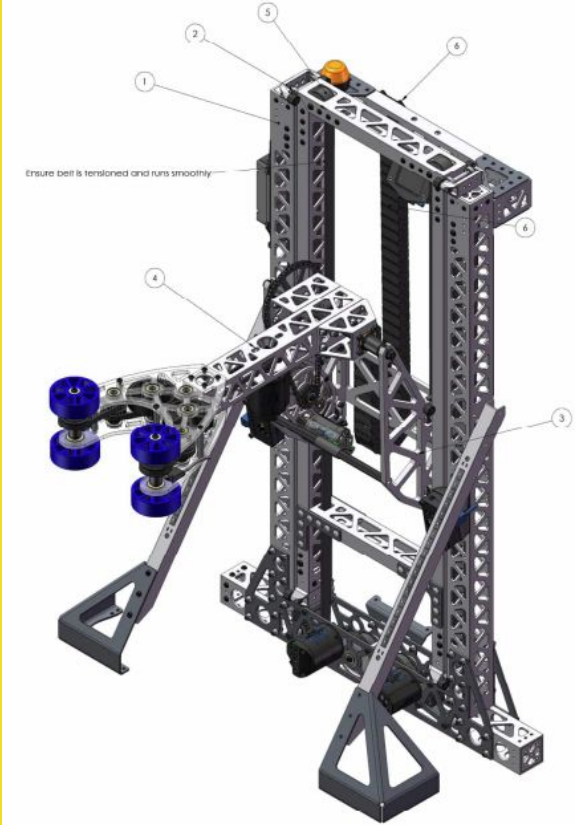


# Design with repairs in mind

- How do you repair your robot?
- If a bearing fails, how long will it take to repair?
  - Do you have a spare?
- Removing large parts of your robot?
- Replacing belts or chain?
- Tension belts or chain



# Mechanical Design

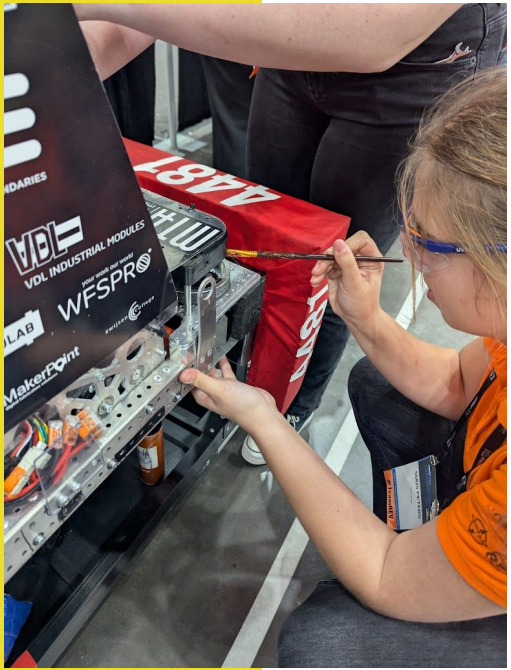
- Scrappy Not Crappy by 604
  - How a low resource team can compete in northern Cali
- Fabworks - online fabrication service
  - Use FRC604 discount code at checkout
- Hot Take: Planetary Gearboxes have a lot of backlash. Only used for rollers and end game (694 Joe Blay)

# Mechanical Design – Backlash

- Reducing backlash for repeatability
- Shim Tape - 4414
- Loctite 609 - Retaining Compound
  - Becareful Loctite is permanent
  - Apply high heat 500F to remove
- Tensions on belts and chains
  - Chain: use a turnbuckle
  - Belt: increase offset on printed pulley.
- WCP has oversize shaft (.505” Hex)


# Mechanical- Grease & debris

- How often do you grease your gearboxes?
- Do you have the gearboxes enclosed to prevent grease from escaping
- Apply Grease with a paint brush or syringe
- Grease Suggestions
  - Syringe Bearing Grease
  - Ceramic Grease
- Grease Threads
- Red Tacky Grease



# Mechanical Design – Thread Locker

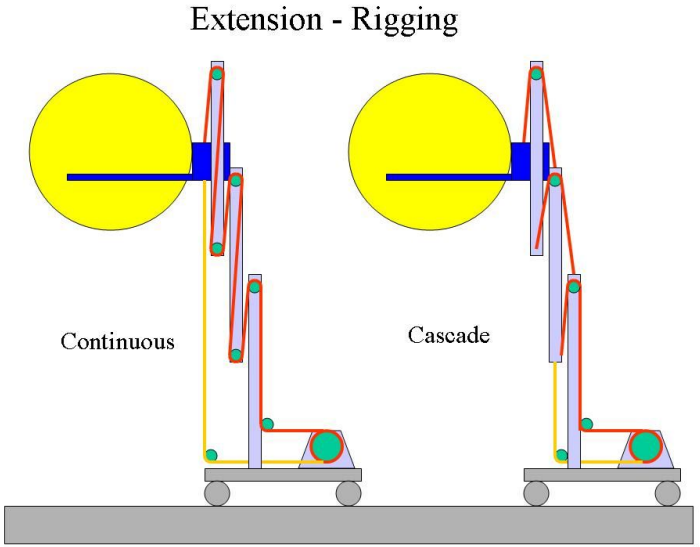
- Loctite threadlocker
  - Blue - 243 - Breakable
  - Red - 263 - Permanent

- Do not use loctite on polycarbonate
  - Makes it brittle and cracks

- Removing red loctite requires heat
  - 500F with a heat gun.

# Mechanical- Elevator

- Elevator Design by Adam Heard
- Cascade Design
- Continuous Design
- Buy bearing blocks from
  - SDS
  - WCP
  - REV

# Mechanical- Standards of hardware

- 3/16” Rivets & #10-32 Bolts
  - #9 Drill can be used for both holes
  - 135 deg split point drills
- Rivets are for permanent fixtures and bolts should be for repairs
- Hot Take: Only use ¼”-20 when needed
- Socket head cap screw vs. button head
- Be careful of the material used
  - Stainless steel will gall (lock up)

# Mechanical- 3D Printing

- Bambu Labs H2S - $1500
- 12 hrs at 100C to dry filament
- PA6 - CF slicer works well
- Check your

# Electrical

- Battery
- Main Breaker
- RoboRIO
- Wiring

# Electrical - Battery

- Batteries in FRC by Juan Chong
  - Don't charge warm batteries
- Label your batteries
  - Keep track of how they perform
- Noco Genius Chargers
- Use a Battery Beak to check charge levels
- Never mount the battery with the leads facing down
- Grasshopper Nut for battery terminals


# Electrical – Main Breaker

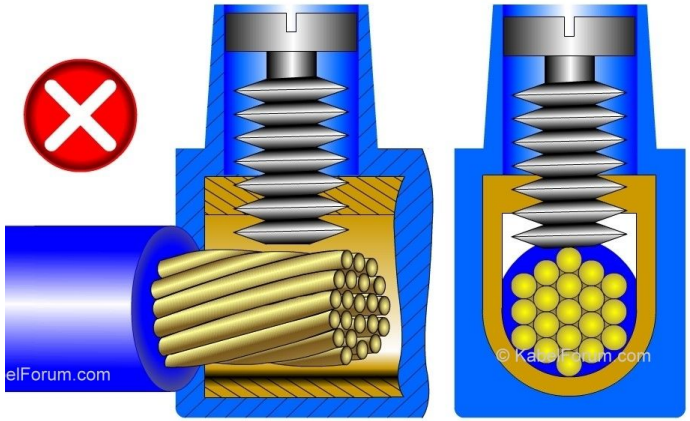
- Mount the main breaker
- Cover your Main Breaker
  - FRC Main Breaker Shroud
- Use ¼”-28 Lock Nuts
  - Mcmaster: 95615A130
  - Use a socket when tightening
  - Loose wires can pop the breaker
- Keep your wire runs short from battery to breaker & PDH

# Electrical - RoboRio (RIP)

- Cover the unused ports with electrical tape or a 3D printed cover
- Use RoboRIO Power Phoenix Push-in Spring Connector
  - AndyMark
- Hot Glue Your Connections
- Use NPN sensors for DI/O

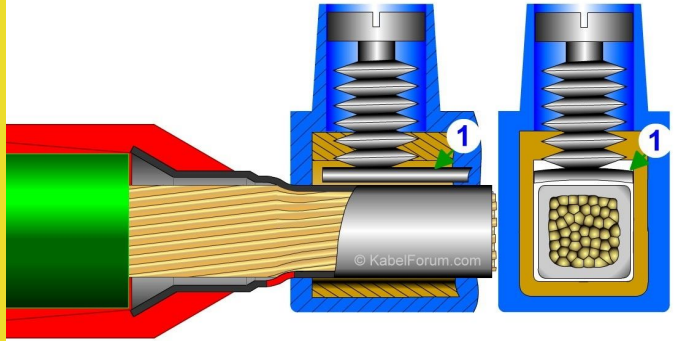

# Electrical - Connectors


- Ferrule crimp your connectors
  - Ferrule crimping kits
  - Prevents damaged wires on some connectors (PDH does not)




- Inline Wagos for quick connection
  - Don't use 221 Wago Connectors for CAN wires

- Check if you can use ferrule crimps

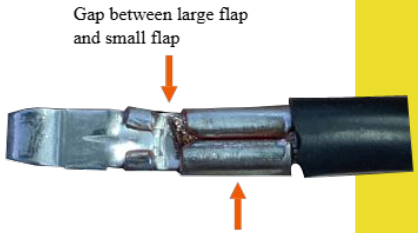
# Electrical - Anderson Connectors

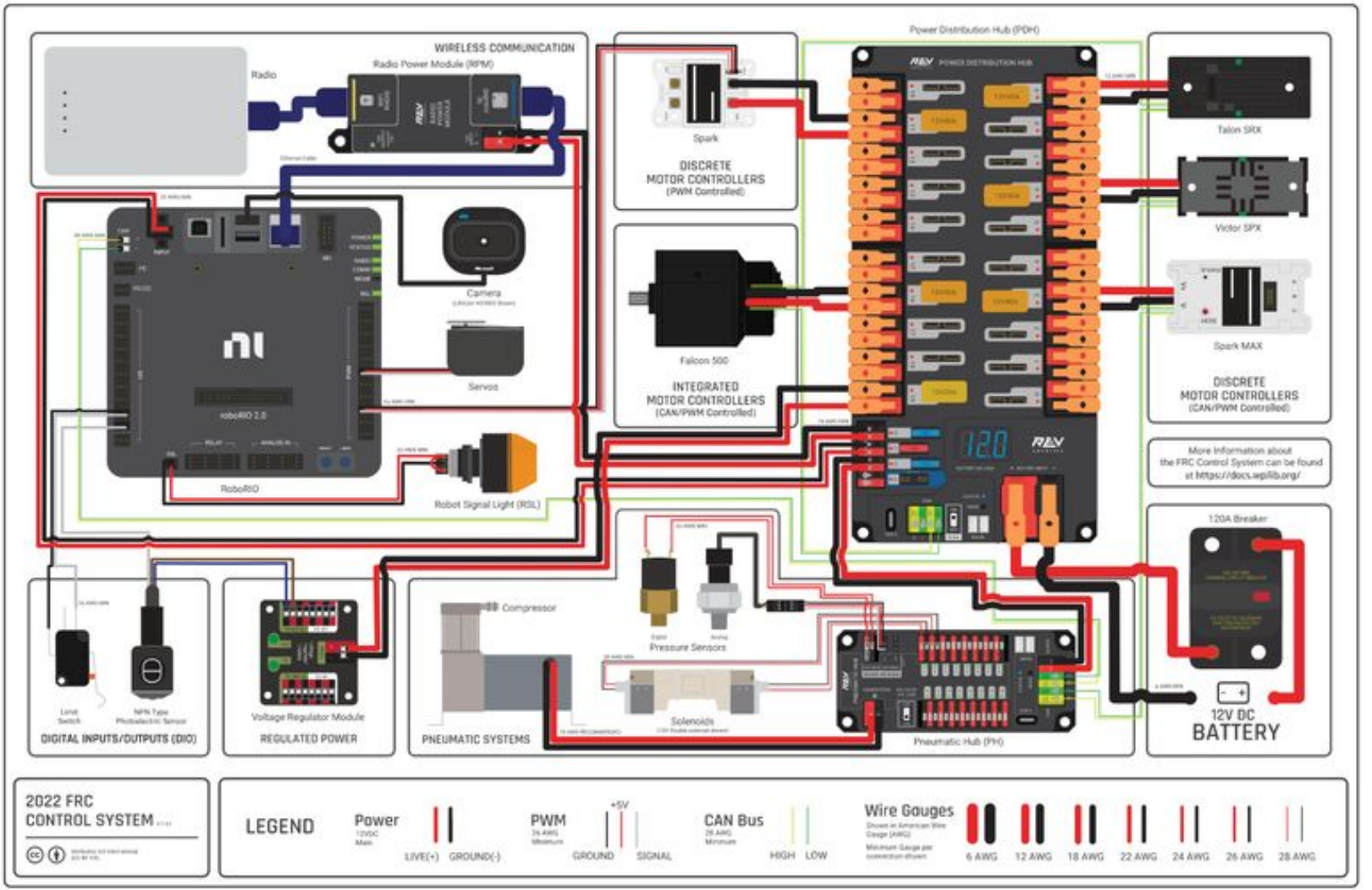
- SB120 & SB50 are keyed differently
- SB50 is the standard red in FRC

- Anderson Powerpole
  - Crimping Video

Bad Connection

Good Connection



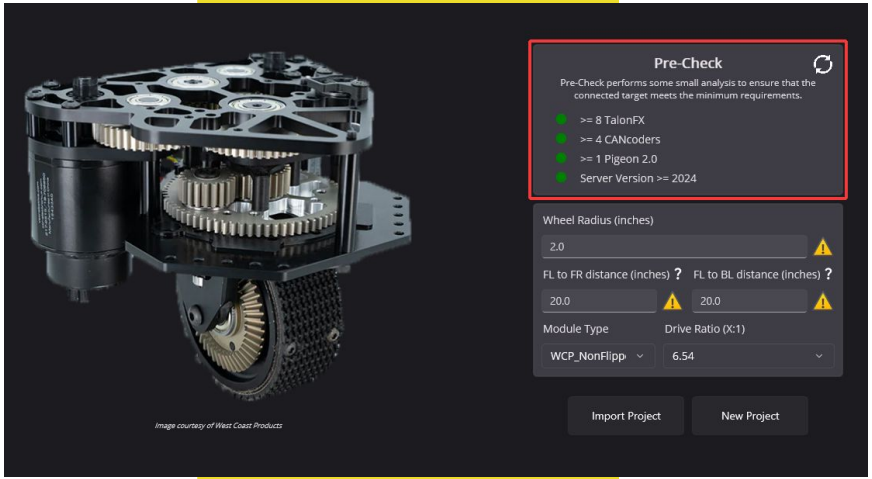


WIRELESS COMMUNICATION
Radio
Radio Power Module (RPM)
Spark
DISCRETE MOTOR CONTROLLERS (PWM Controlled)
Power Distribution Hub (PDH)
Talon SRX
Victor SPX
Spark MAX
DISCRETE MOTOR CONTROLLERS (CAN/PWM Controlled)
Camera
Servos
roboRIO 2.0
RoboRIO
Robot Signal Light (RSL)
Falcon 500
INTEGRATED MOTOR CONTROLLERS (CAN/PWM Controlled)
More information about the FRC Control System can be found at https://docs.wpilib.org/
120A Breaker
12V DC BATTERY
Limit Switch
NPN Type Photoelectric Sensor
DIGITAL INPUTS/OUTPUTS (DIO)
Voltage Regulator Module
REGULATED POWER
Compressor
Pressure Sensors
Solenoids
PNEUMATIC SYSTEMS
Pneumatic Hub (PH)
2022 FRC CONTROL SYSTEM
LEGEND
Power
LIVE(+)
GROUND(-)
PWM
+5V
GROUND
SIGNAL
CAN Bus
HIGH
LOW
Wire Gauges
6 AWG
12 AWG
18 AWG
22 AWG
24 AWG
26 AWG
28 AWG

# Electrical - Basics

- SECURE the battery to your robot
- Zip tie your battery leads every match
- Wiring Basics
  - Avoid pinch points & add strain relief
  - Layout excess wire to reduce stress on wires
  - Check wire runs with full range of motion
  - Pull test your connections
  - Hot glue your connections
    - Isopropyl alcohol breaks up hot glue

# Programming

- Smart Dashboard
  - Gyro status before a match
  - Status of your robot
- Setting current limits on your motors
- Vision Processing
  - Limelight (Plug and Play)
  - PhotonVision (More Choices)
    - ThriftyCam
- CTRE swerve generator
  - Have to use all CTRE products
  - CTRE Swerve



# Programming - Vision

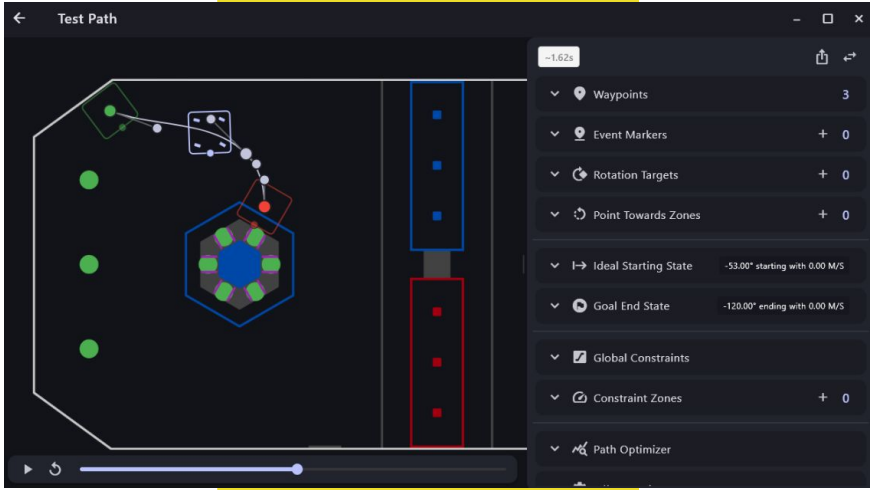
- Beyond the Coprocessor: Lessons in FRC Vision & Localization
- Camera mounts out of TPU
- Vision Processing
  - Limelight (Plug and Play)
  - PhotonVision (More Choices)
    - ThriftyCam

# Programming

- State machines for code structure
  - Detecting game pieces and changing state
  - Work through your process
- LED on the robot
  - Error Status before matches
  - Game piece acquired or signal
- Gamepad vibrates when the robot is out of sight of an AprilTag
- Gamepad vibrates when game piece is acquired

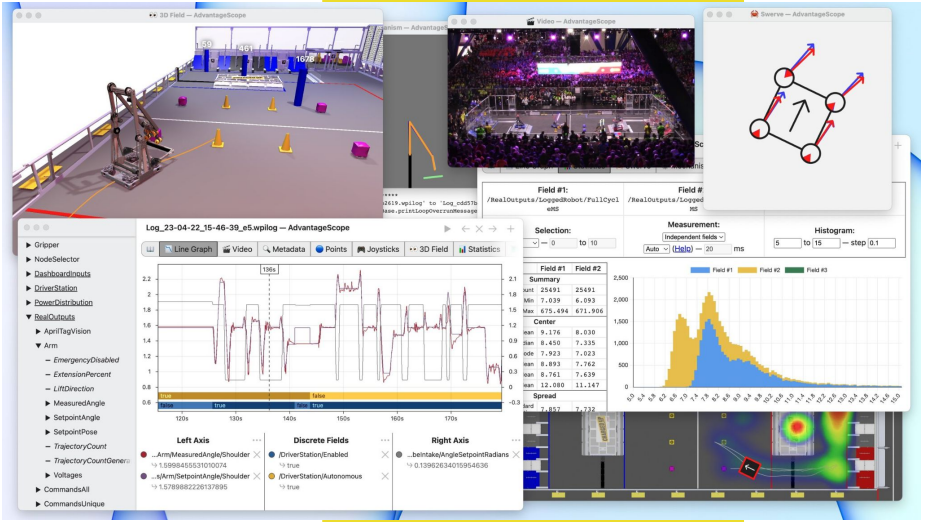
# Programming - Auto Mode

- Path Planner
  - Plan out your auto modes
  - Create different modes during competitions
- Keep your paths smooth
- Run your Auto modes
  - Know your variables
    - Wheel diameter
    - Where do you line up
- Hot Take: Check your wheel treads during competition.



# Programming - Logging

- 6328 Software resources
  - Advantage Scope
  - Advantage Kit



- These tools allow you to track and log information during matches.

# Driver Practice

- Have your mentors drive the robot
- Don’t be afraid to break your robot.
  - Have your driver know the limits of the robot
- Listen to your robot during practice
  - If you hear a swerve pod dragging STOP
- Have your pit crew ready during practice
  - Have them do homework
- Hot Take: auto scoring does not replace drive practice

# Driver Practice

- Everyone on the drive team needs to practice (this applies to the drive coach as well)

- Drive your robot into the ground
  - Figure out how to break your robot at your shop (To learn how to repair)

- Record your practice runs
  - Keep track of how many you score
  - Focus on the failures more than successes
  - See what wears on the robot
    - Repairs or maintenance between matches (254 in 2017)

# Competition - Pit

- **System Check Before & After Every Match**

- Make sure your pit crew is locked in and ready to cook.
  - Train your pit crew on repairs
  - Train your pit crew on how to talk to Judges

- Have a Pit Checklist
  - Keep track of your batteries
  - Check your treads and other wear parts

- Don’t joke around with pit scouters

# Competition - Scouting

- Are other team playing the game differently?
  - Bounce back pass (2014)

- Having your strategy team know how efficient alliance partners are.

- Your drive team should not be doing match strategy
  - Don’t need your drive team stressed before a match

# Competition - Alliances

- The alliance captain should make the alliance special
  - Every team needs to buy into the alliance

- If you are the alliance captain check on your partners during matches and before playoffs

- Alliance captains look to make improvements to alliance partners if needed
  - 1923 told us to hot glue our connectors

# After the Competition

- After competition meeting
  - Discuss what went right and what went wrong
- Corrective and Preventive Action (CAPA)
  - Develop a plan to fix the problems
- Rewatch matches
  - See where to speed up cycle time
  - The rush of competition is over and see what your robot truly did

# Rookie Teams Tips

- Enjoy the journey & learn as much as you can.
  - TCA worksheets
- Start off with the Kitbot first and build it solid, Ask another team to inspect your robot
- Mount the battery
- Zip tie your battery leads
- Don’t be afraid to ask for help.


# 2nd year Teams Tips

- Invest in swerve
  - SDS, WCP, Thrifty
- FRCdesigns.org
- Buy a Bambu Lab 3d Printer
- Look at the Ri3D & open alliance
- Have a support team to ask questions and bounce ideas off of
- Don’t be afraid to ask for help

# Decent Teams Tips

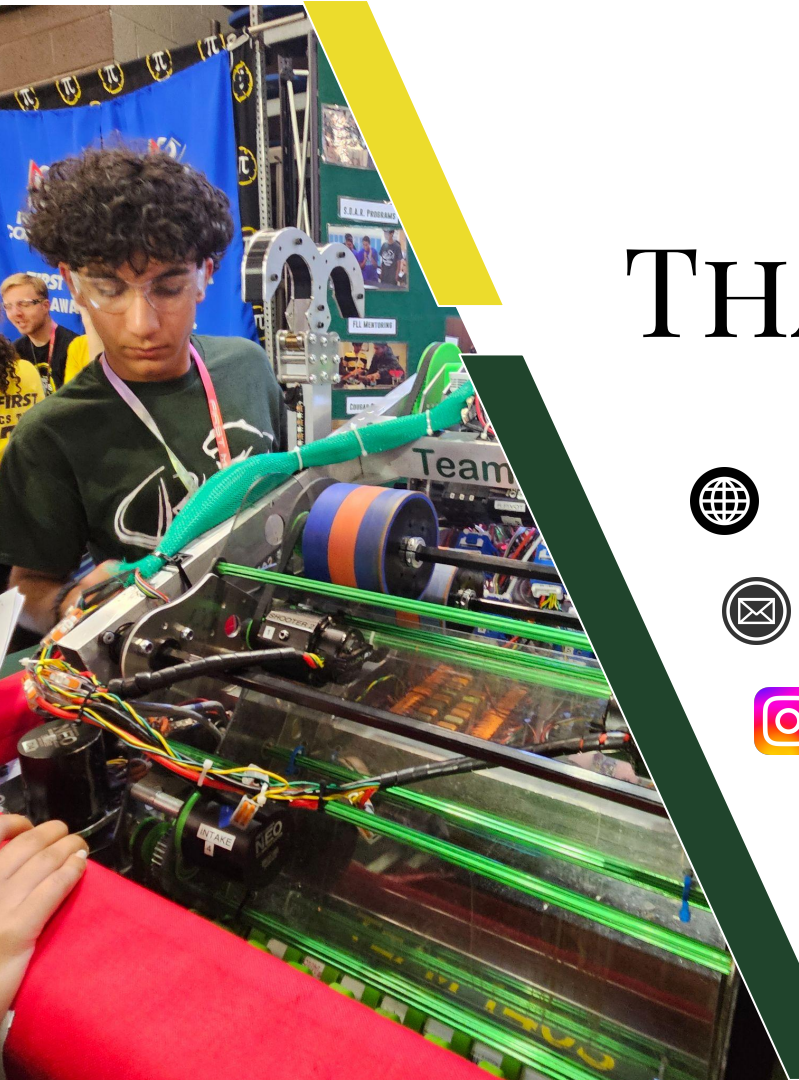
- Research different robots
  - TBA
  - Behind the Bumpers
  - Make friends (Discord)
- Build & fail faster
- Don’t copy designs without knowing all the details or have the time to flush out the designs
- Invest in developing your vision software
- Develop a community

# Good Teams Tips

- Develop processes
  - Reduce your wasted time during build season
- Don’t do everything, your team is not 254
- Build better team & robot systems to focus on small details
- Build other teams robots during the offseason
- Make friends with other teams and share knowledge and experience

# Flowers & Thank you

- Dr Eugene Fang
- Mike Corsetto
- Tyler Holtzman
- R.C.
- Joe Blay
- Billfred Leverette
- Andrew Hartnett
- Christine Low




# Thank you

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