DROPSHOT

2016

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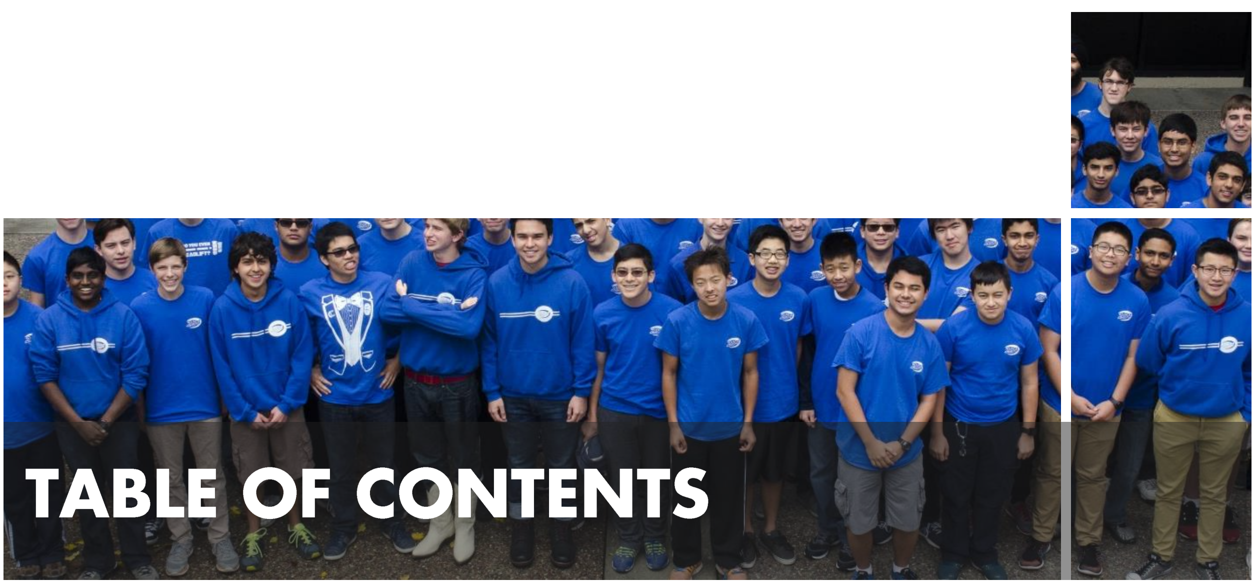

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STRATEGY

- requirements
- potential robots
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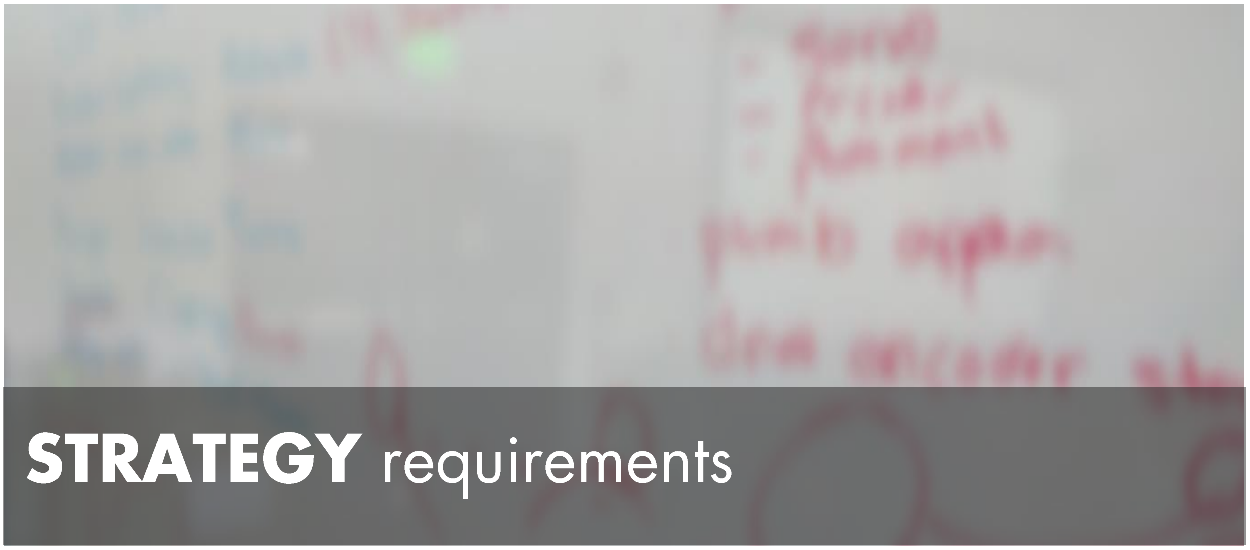


STRATEGY requirements

Annually, we begin kickoff as most teams do, by attending the FIRST Kickoff. Due to the size of our team, only a few of our mentors and leaders will attend in person, while the remainder tune in to the webcast. Later that same morning, the entire team will gather for our own Kickoff.

Once the whole team is up to speed on the game animation, we break into small groups where students share their initial thoughts and reactions and begin discussing choke hold strategies and other key game features. When the team comes back together, each small group presents its conclusions to the larger group. Then – after a thorough, line by line, review of the game manual – the team will analyze game play and scoring to start to develop a strategy for the game. Once the team has created a strategy that optimizes our ability to win matches, we begin creating potential robot concepts. These concepts aid in our designing of the robot.

STRATEGY potential robots

#1: "Manut Bol"

- Permanently mounted high exit point shooter
- Pros
  - Simple and robust
  - Flatter shot trajectory
  - Compatible with turret
- Cons
  - Passing under low bar is impossible
  - May increase maximum "shooting only" cycle time, miss out on 10 points if partner can't do it, or be forced to do all 4 groups of defenses for breach
  - Portcullis is more difficult
  - Need to manage center of gravity

#2: "Michael Jordan"

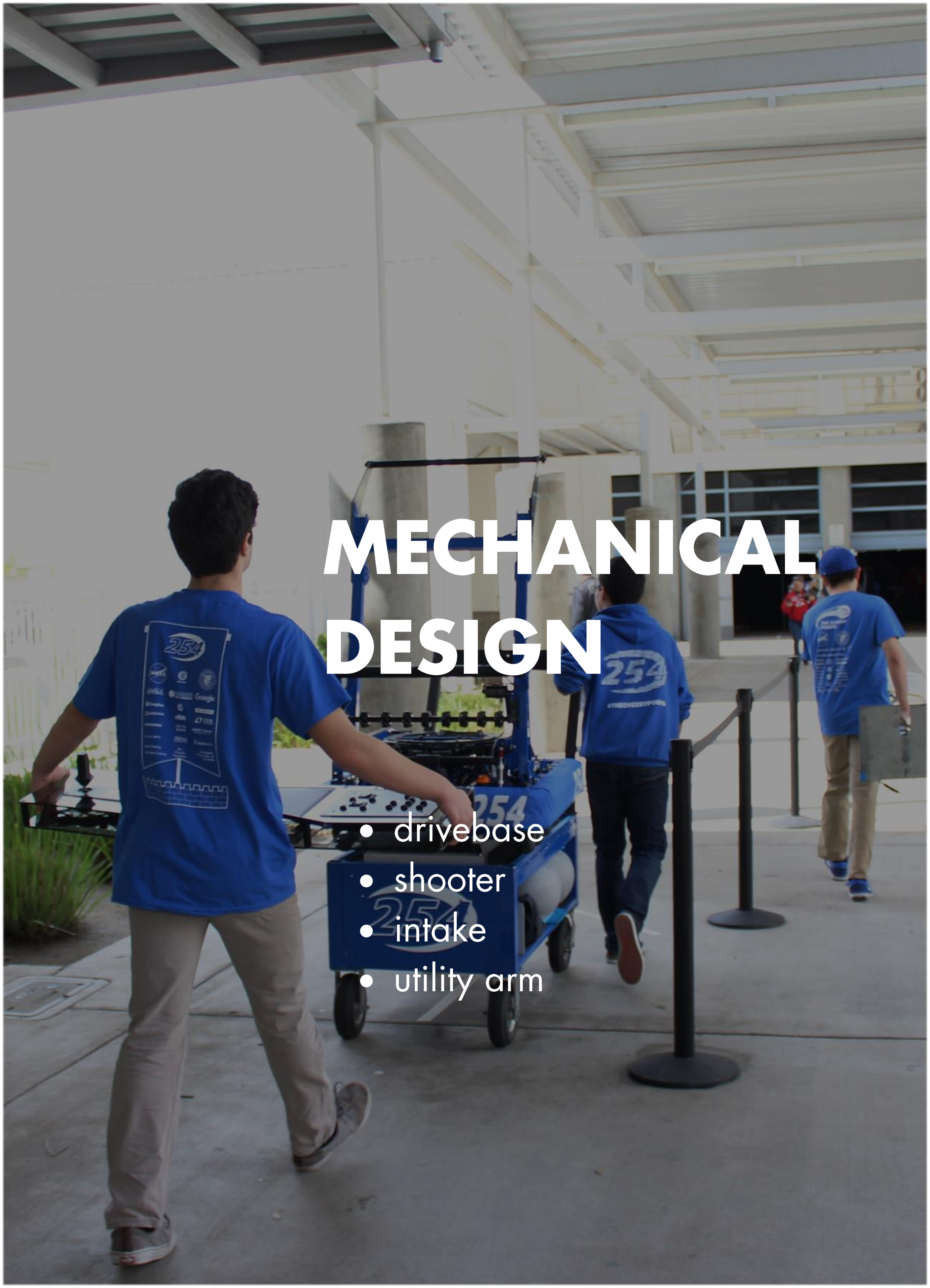
- High exit point shooter that can also stow
- Pros
  - Can go under low bar and portcullis easily
  - Unlockable shot with flatter shot trajectory
- Cons
  - Increased complexity and design time
  - Extra non-rigid degree of freedom between shooter and base, and may lead to consistency issues
  - Need to stow/deploy shooter when traversing low obstacles, which takes extra time

#3: "Steph Curry"

- Permanent lower exit point shooter (may still need to stow)
- Pros
  - Simple and robust design
  - Can go under low bar and portcullis easily
  - Low center of gravity
  - Compatible with a turret
  - Confidence in vision tracking software and driver ability
- Cons
  - Blockable Shot
  - We must rely on base lock, driver skill, and software to guarantee shots

STRATEGY conclusions

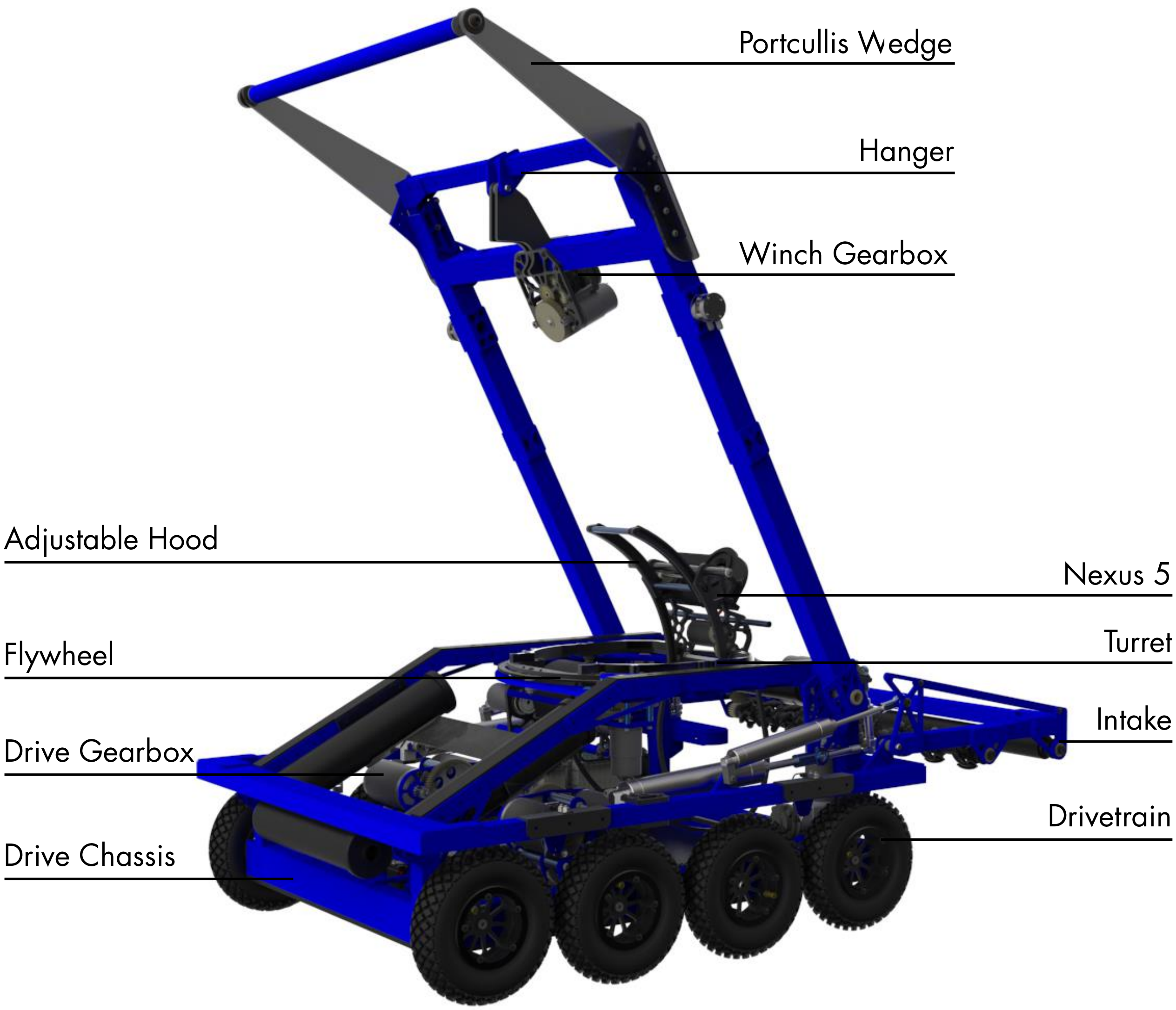
- "Steph Curry" selected for final design
    - We choose the "Steph Curry" concept for a variety of different reasons. Having a Low Bar robot guaranteed the ability to obtain a breach without needing to damage the Sallyport or Drawbridge. Although having a permanently low robot meant having a blockable shot, integrating a turret and vision tracking software ensured that the robot could shoot from anywhere, in any orientation in the courtyard regardless of what defense was being played against us. Overall, we concluded that the "Steph Curry" concept was the best concept for optimizing scoring.



MECHANICAL DESIGN

- drivebase
- shooter
- intake
- utility arm

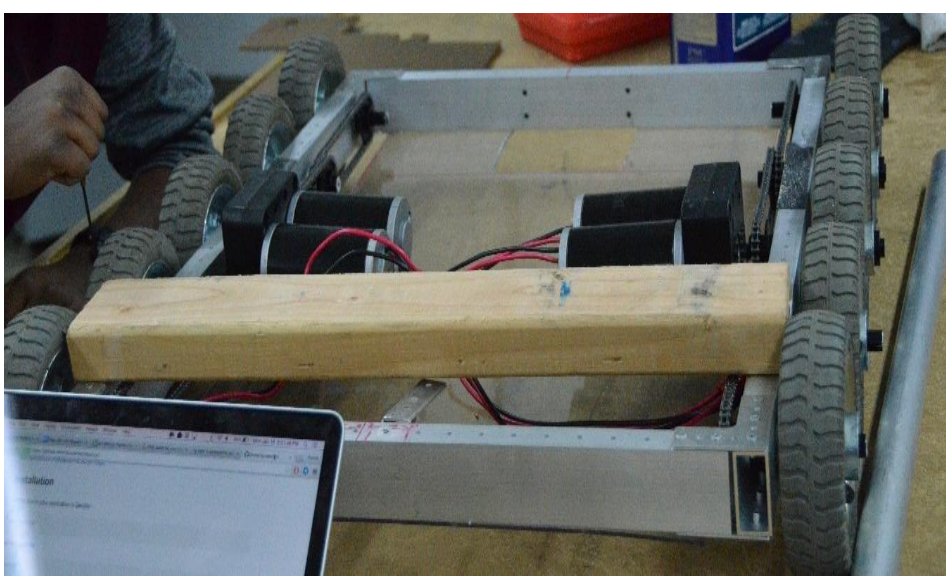
DROPSHOT final mechanical design



DRIVEBASE prototyping

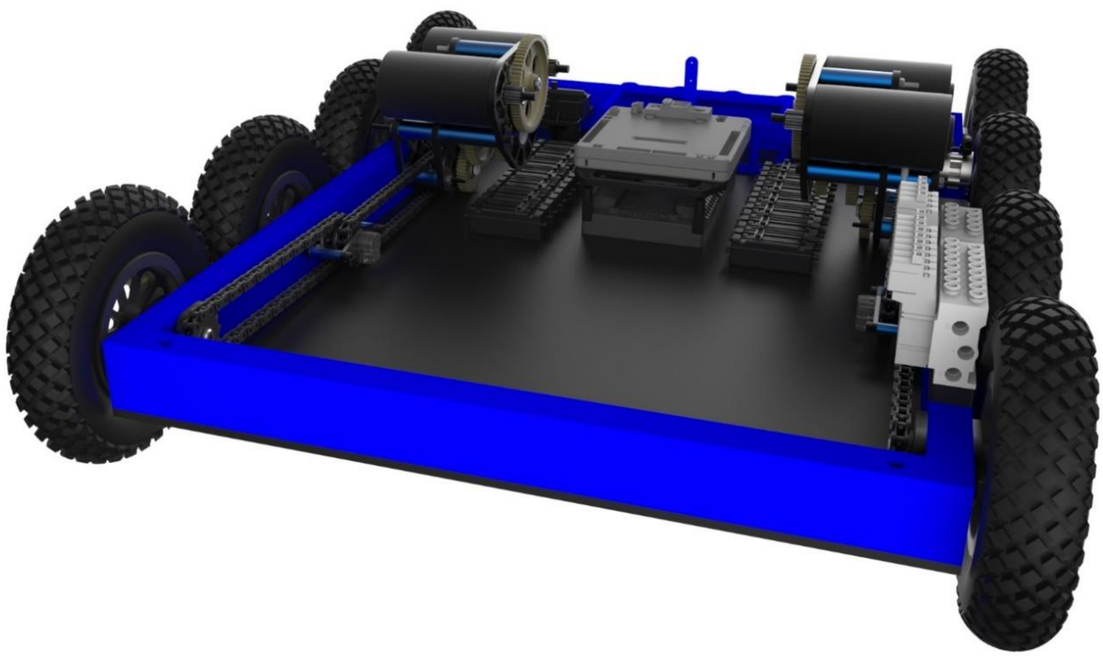
Goals:

- Approach angle of 90° is ideal for crossing the rock wall.
- We chose not to use tank treads because of potential for failure during a match, complicated chassis, expensive price, our lack of experience with these kinds of drivetrains, and lowered maneuverability if used with Steph Curry
  - We want our drivetrain to replicate the benefits of constant contact (as in tank treads) but using the simpler and more familiar West Coast Drive
- Testing
  - Six 8″ wheels
    - Pro - Has fewer wheels so it's lighter, cheaper, and simpler
    - Con - Rock wall could get in between wheels and stop the robot
  - Eight 8″ wheels
    - Pro - Can traverse rock wall and moat without risk of getting stuck
    - Con - More wheels lead to more weight, price, and complexity
  - Ten 6″ wheels
    - Pro - Can traverse rock wall and moat without risk of getting stuck
    - Cons
      - More wheels lead to more weight, price, and complexity
      - Does not have 90° approach angle
- We decided on the eight 8″ wheels due to their performance in our testing



10 Wheel, 6 Inch Drive

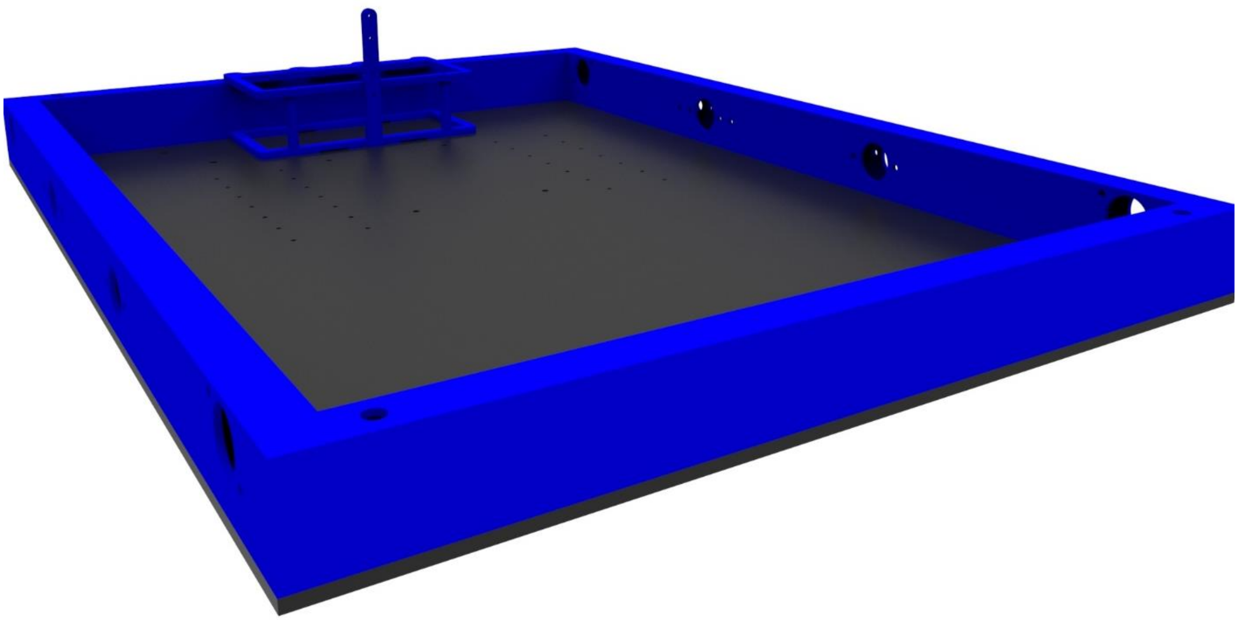
DRIVEBASE drivetrain



- 8-wheel "West Coast Drive," with an outer wheel rise of .3125"
- Used 8" pneumatic wheels with a tube pressure of 25 PSI
- #35 Chain runs along the side rails running on 12 tooth sprockets to clear the bellypan
- Utilizes 2 SRX Mag Encoders

8" Pneumatic tires

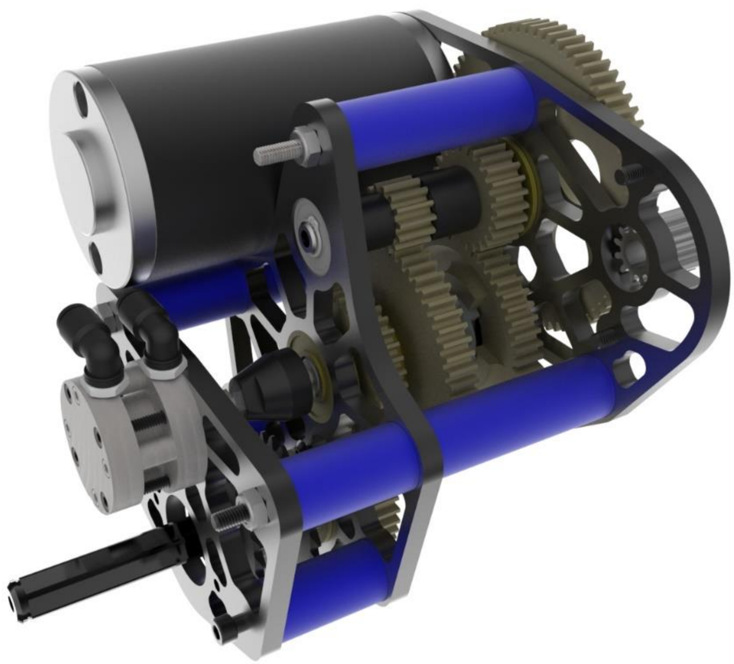
DRIVEBASE chassis



ABS
belly pan

- 21.75" wide
- 29.25" long
- Frame is 1" x 2" x ⅛" Aluminum box tubing
- ¼" thick laser cut ABS belly pan features tapped holes for mounting electronics and is mounted to the chassis using 172 countersunk rivets

DRIVEBASE drive gearbox

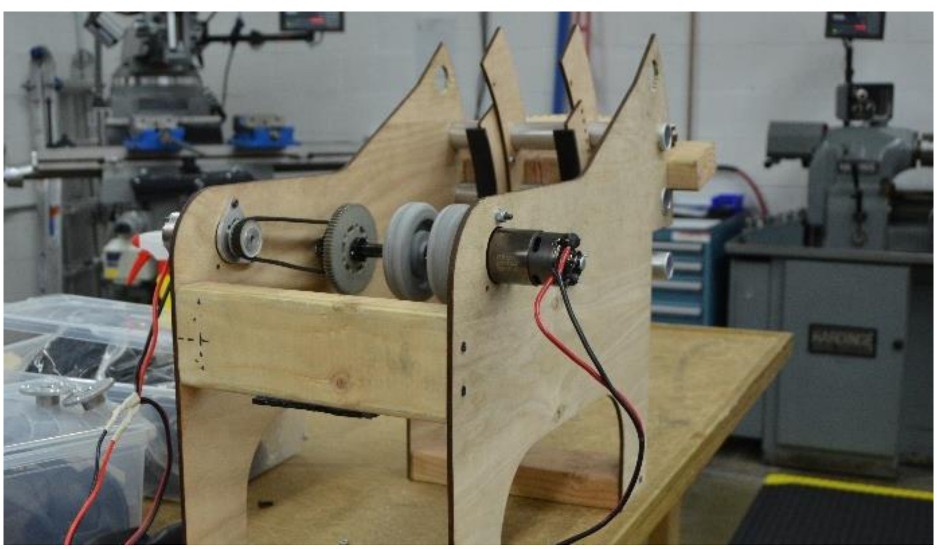


- 2 CIM motors per gearbox with 2 different speeds and 2 stages of reduction
    - Low gear is 25.71:1
        - Theoretical Top Speed: 7.09 ft/sec
    - High gear is 12.5:1
        - Theoretical Top Speed: 14.59 ft/sec
    - Gearboxes need three stages because of larger wheel size
- Designed to accept multiple ratios in one gearbox
- Flipped CIMs and cylinders
    - Allows more room for electronics placement
    - First experience using this method

Inverted CIM 2 – speed gearbox

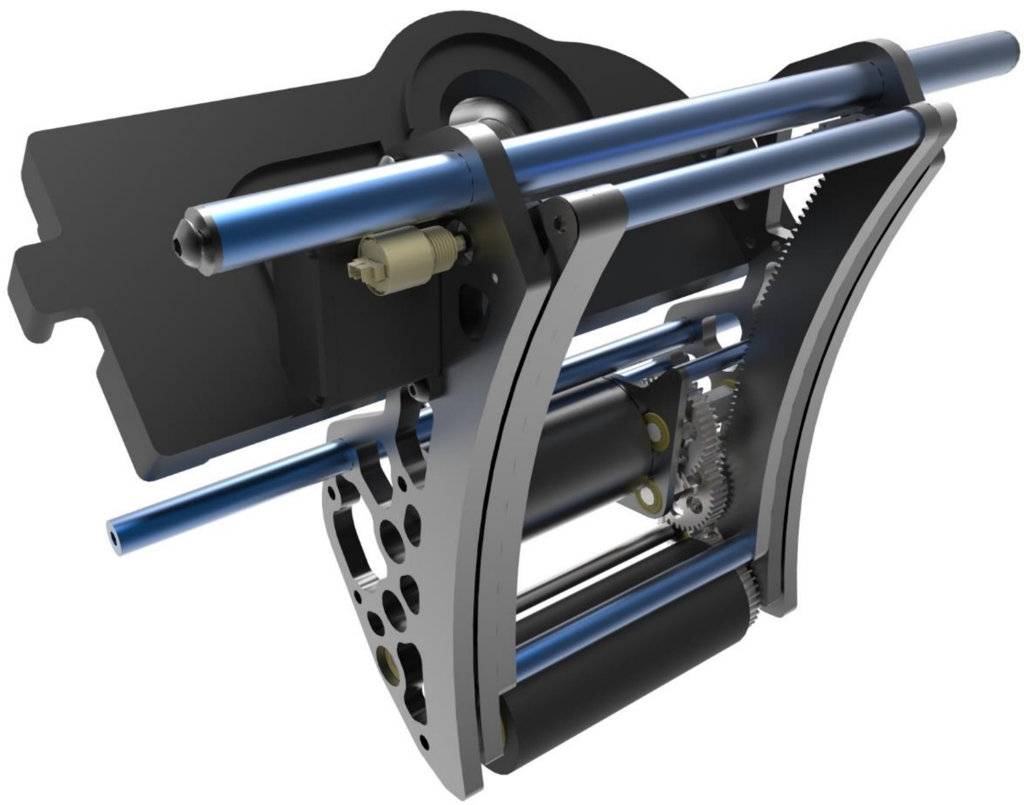
SHOOTER prototyping

- Catapult
  - Pro - Packages nicely with a low robot
  - Cons
    - Ball has no spin when shot
    - Hard to package on the turret and incompatible with Steph Curry
- Dual flywheel
  - Pros
    - Other teams have been successful with this type of shooter
      - In 2014, 1114 had a successful combined intake and shooter
  - Cons
    - Harder to use with the turret
    - Adjustable shots are harder as the entire assembly needs to move
- Mono flywheel with hood
  - Pros
    - We are experienced with this type of shooter
      - Parts are easy to make with our tools, especially the laser cutter
      - Can be better tuned with software
    - Easiest shooter to package with the turret
  - Cons
    - Hardest shooter to package in the robot
      - Hood needs to stow to go under the low bar
- We decided on the single flywheel as it was the fastest and most accurate mechanism during prototyping and the team has had success with this mechanism in the past.



Laser cut shooter

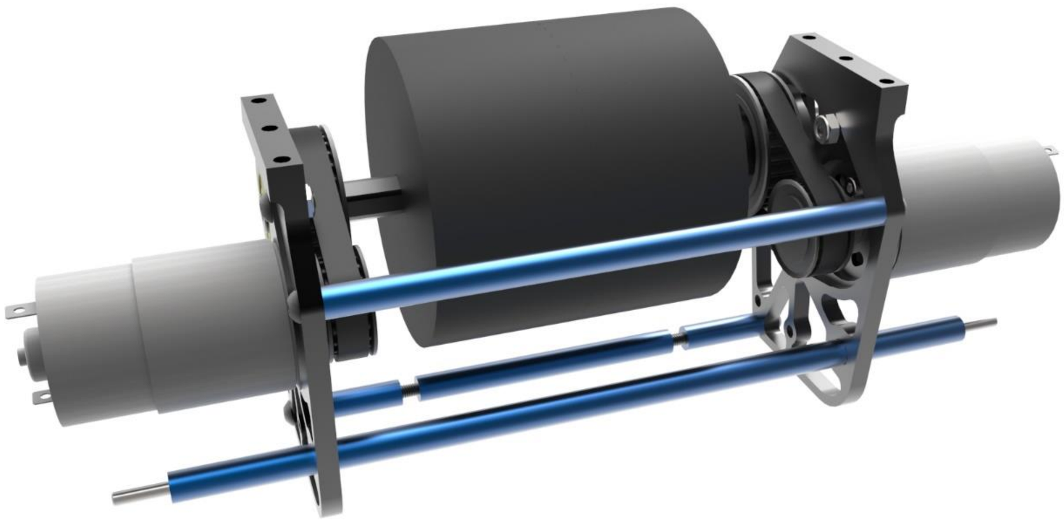
SHOOTER hood design



Adjustable hood

- Can stow into the robot for Low Bar passage
- Sector gears on the back are driven by the servo to adjust shot trajectory
- Utilizes a MA3 Miniature Absolute Magnetic Shaft Encoder to track the angle of the hood.
- Nexus 5 with a ring light for vision processing
- A surgical tubing feeder roller on a dead axle is driven by a BAG motor with a compact 5-stage reducing using lightened 32DP gears.
    - The roller constantly contacts the ball and allows for accurate intaking and exhausts.

SHOOTER flywheel



- Similar to our 2014 flywheel
- Belt driven by two 775 pro motors in a 30:19 reduction
- Two Fairlane wheels spinning at about 6000 RPM
- Use safety wire to keep wheels from expanding too much at high RPMs.

Single Flywheel Shooter

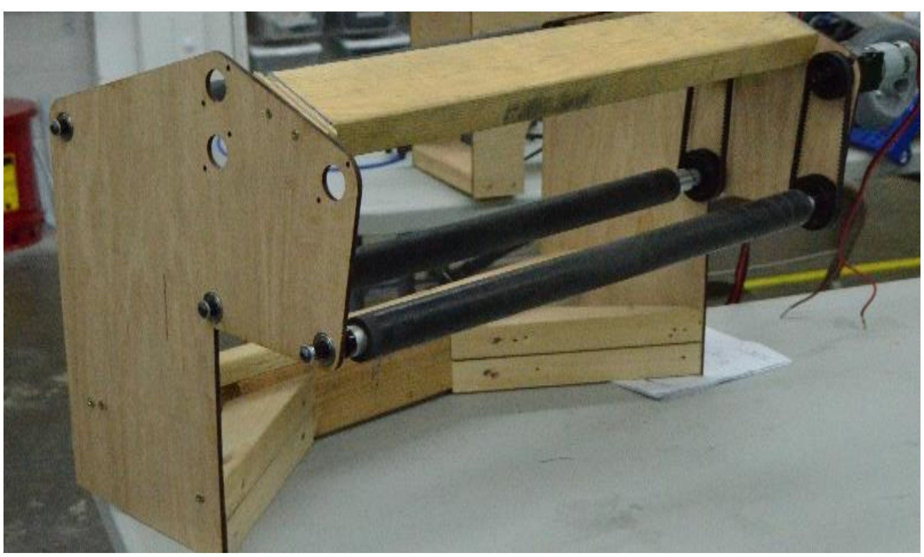
SHOOTER turret

Automatic aiming turret

- Shooter rails
  - ¼" "Aluminum horseshoe" with rails guide the Boulder into the shooter
- Turret
  - 322 tooth ⅛" water jetted aluminum turret gear, driven by a 775 Pro motor with a 3-stage reduction
  - Allows the shooter system to rotate 220˚
- Sensors
  - Utilizes limit switch connection capabilities on the SRX Mag Encoder
    - Two West Coast Products hall effect sensors act as the soft stops for the turret
  - Utilizes a SHARP sensor on the belly pan centered in the turret which allows for the feeder roller to consistently load the ball into the turret while driving and aiming

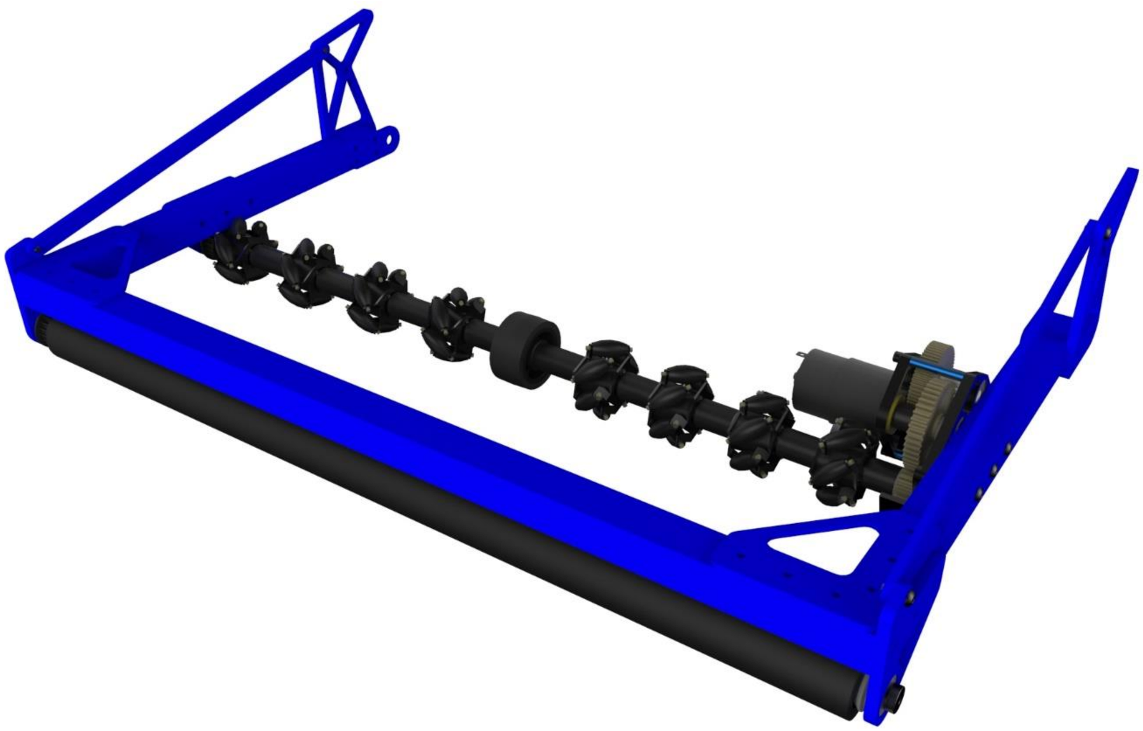
INTAKE prototyping

- Goals
    - Wide intake that centers the Boulder
    - Simple, lightweight, and robust to take a beating
    - Does not require a cut in chassis
    - No dead zones in ball path
- Testing
    - Passive Funnel
        - Pros:
            - No extra motors required to center the ball
            - Fewer moving parts to fail
        - Cons:
            - Complex to package in the robot, must fold up to go over rock wall
                - Can therefore go over defenses only one direction
    - Delphi Intake
        - Pros:
            - Proven intake, so little prototyping is required
        - Cons:
            - Having 6 shafts adds significantly to complexity and motor usage
            - Past experience using polycord intakes in 2012 and 2009 showed that it's difficult to work with
    - Mecanum Wheels
        - Pros:
            - Simple, and uses only one motor
            - Lightweight
        - Cons
            - Wheels are expensive
            - Lots of small parts



Surgical tubing intake with passive funnel

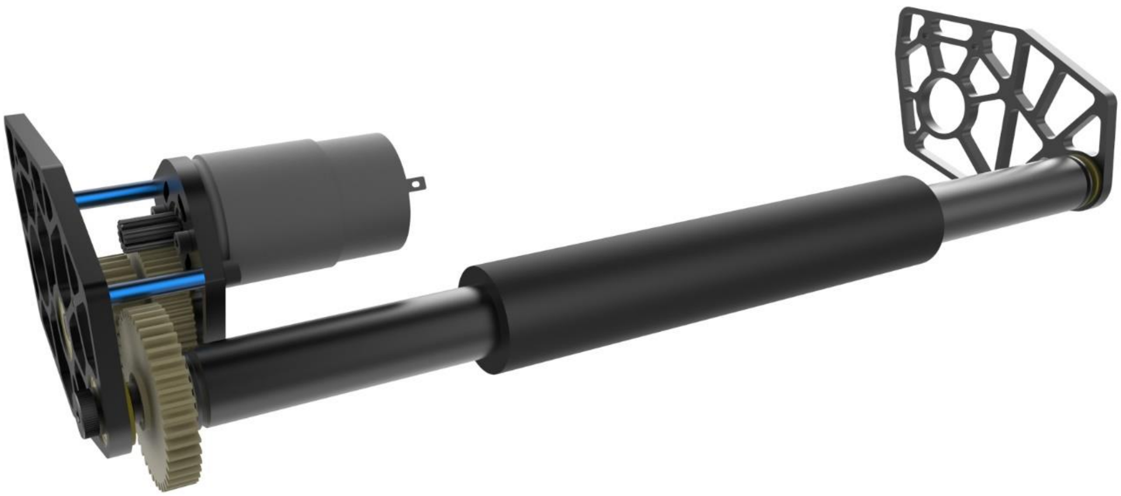
INTAKE mecanum roller



1st time using mecanum wheels

- Inner roller consists of eight 2” mecanum wheels that funnel Boulders along the bumper until they reach the bumper cut-out
- Driven by a 775 Pro motor with a 2-stage custom gearbox to produce a 7.14:1 gear reduction
- Outer roller is 2” OD surgical tubing
- A SHARP sensor located on the belly pan under the feeder roller allows for consistent ball intaking into the robot as well as prevents the robot from intaking multiple balls

INTAKE fixed roller

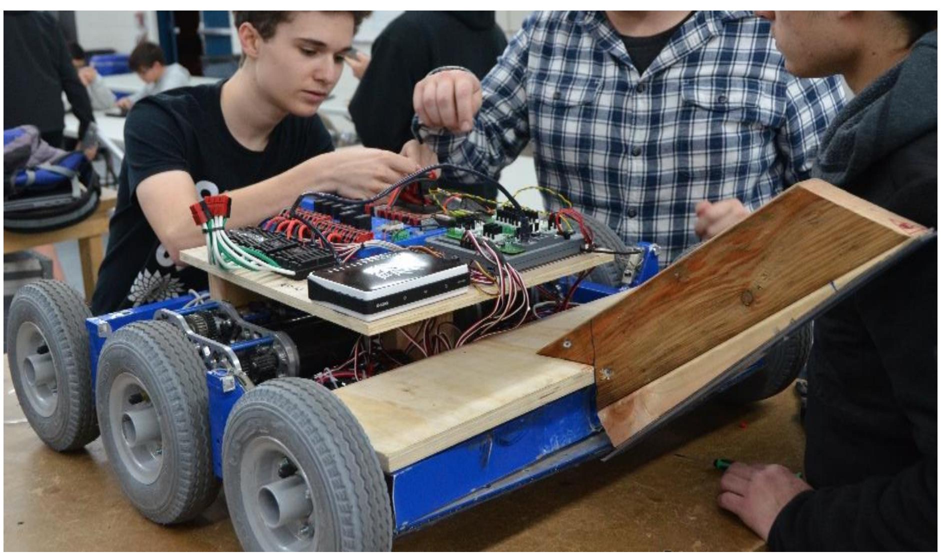


- Made of a 2" OD surgical tubing roller which spans the width of the bumper cut-out
    - Designed to get the Boulder over the side rail and into the shooter loader, while also eliminating the deadzone in the ball path
- Driven by a 775 Pro motor with a 2-stage custom gearbox to produce a 7.14:1 gear reduction

2 stage custom gearbox

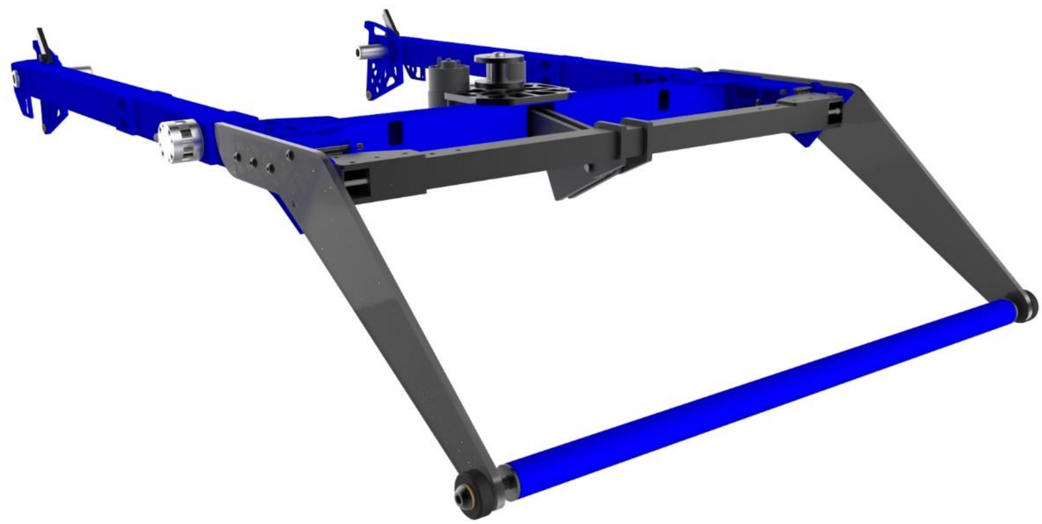
UTILITY ARM prototyping

- Goals
    - Robust and stiff arm
    - Can be used for Cheval De Frise and Portcullis, and doesn't impair crossing other defenses
    - Passive crossing of Cheval De Frise and Portcullis, without actuating arm
- Testing
    - Inverse wedge
        - Pros:
            - Swap between Cheval de Frise and Portcullis modes
                - Start off at 45° and flip to -45° to handle different defenses
            - In theory, could drive over Cheval de Frise without stopping
        - Cons:
            - Hard to make it fit on the robot
                - Trouble clearing bumpers and working effectively
            - Prone to breaking if someone hits the arm
    - Fixed angle
        - Pros:
            - Fixed 45° from the ground
            - Arm goes all the way down for Portcullis
            - Lifts up and presses down on Cheval de Frise to cross
        - Cons:
            - Cheval de Frise crossing is slower than inverse wedge (in theory)



Inverse 45 degree wedge

UTILITY ARM wedge



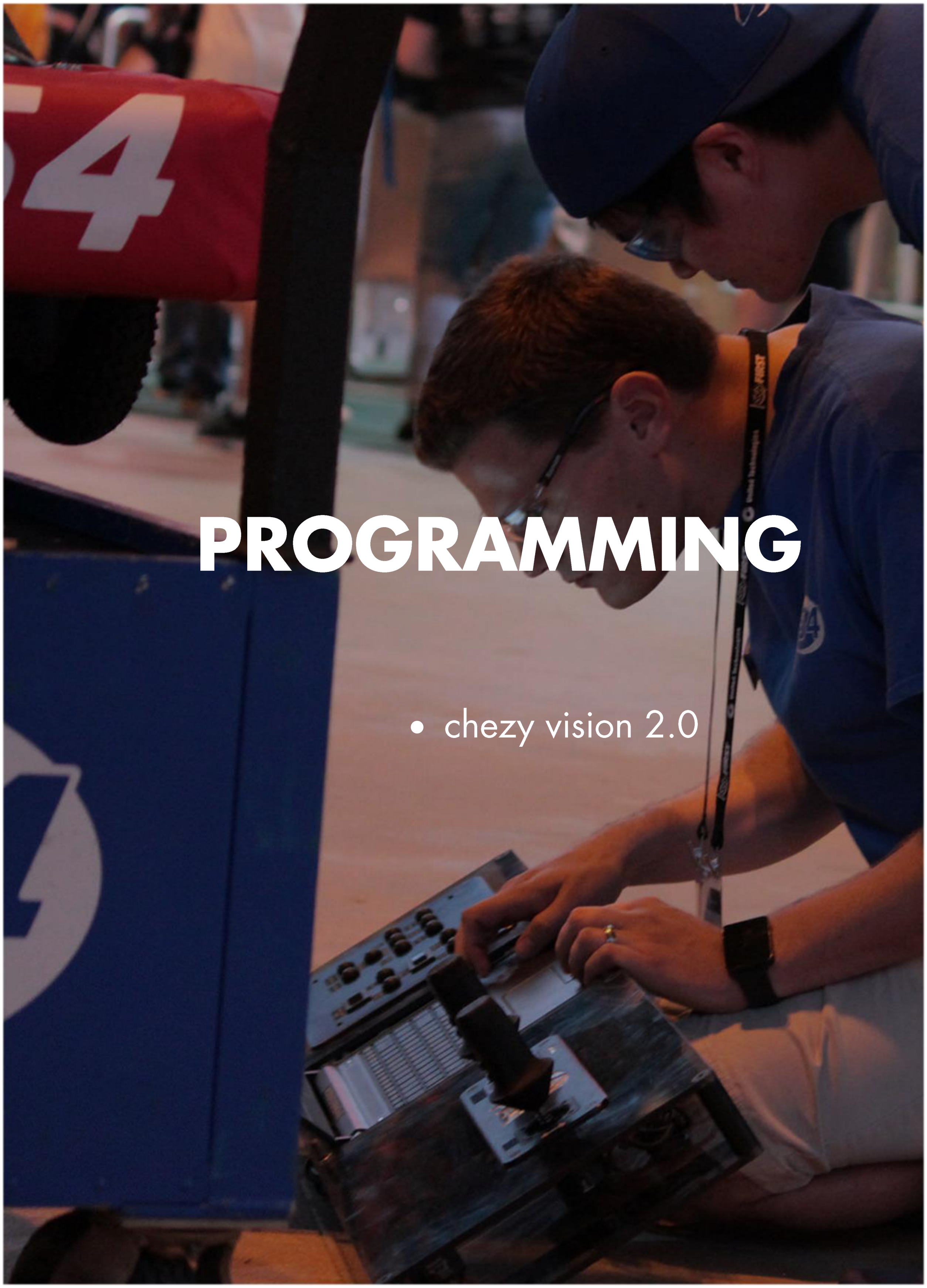
Simple 45 degree Wedge

- Large arm lifted by two 1.5" bore pneumatic cylinders allows the robot to cross the Cheval de Frise and Portcullis and holds a hanger to scale the Tower.
    - Portcullis
        - The arm rests on the bumpers and a 45° wedge allows for the robot to passively drive underneath the portcullis at high speed
    - CDF
        - Arm lowered onto CDF, dropping the panels allowing the robot to drive over

UTILITY ARM hanger

Winch design

- The hanger arms are sprung upward with surgical tubing and are stowed in place by two pancake pneumatic cylinders.
- Retraction uses a ratcheting winch driven by 2 775 Pros in a 2-stage gearbox with a 21:1 reduction.
- High-tensile strength, low-stretch Dyneema cord runs from the winch around a pulley at the hook and attaches to the front of the superstructure
    - As the cord reels in, the telescoping hanger is retracted while the front, cantilevering, end of the robot is also lifted. This prevents the front of the robot from sagging and hanging below the minimum threshold



PROGRAMMING

- chezy vision 2.0

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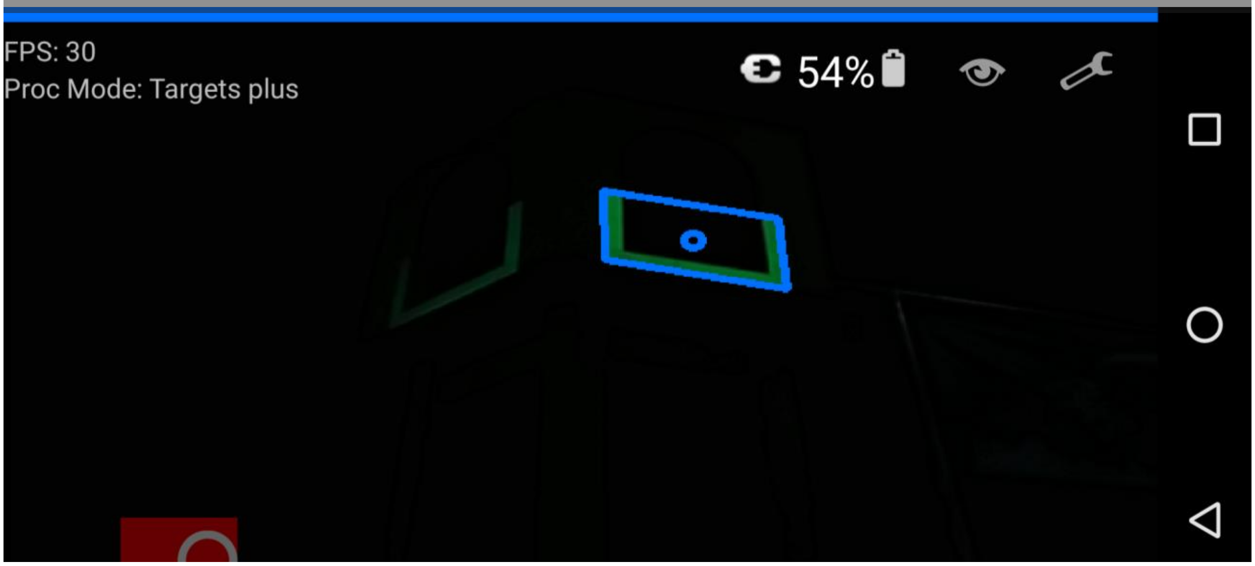
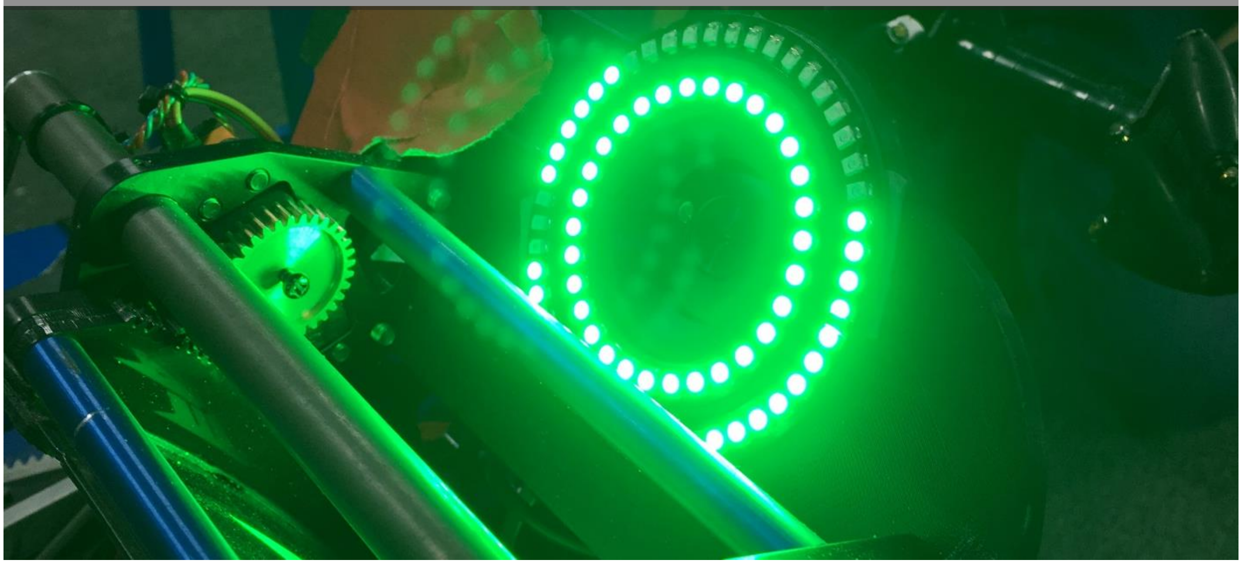
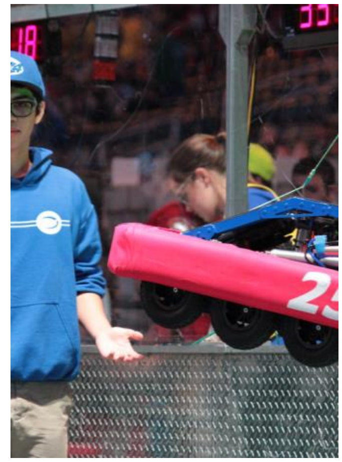


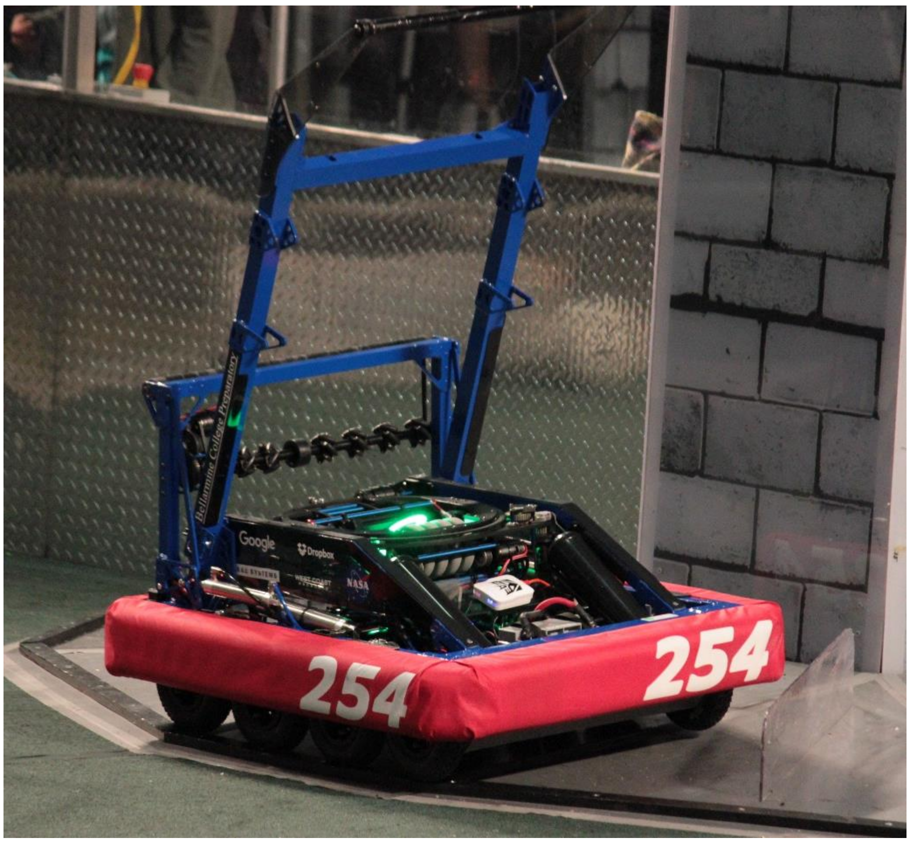
- Custom developed Android app running on a Nexus 5 phone detects the goal
  - Goal is detected by receiving reflected targeting light
    - Light source and camera are part of one assembly
      - Light source shines on target
      - Light is reflected by target to the camera
    - Reflected light is identified by:
      - HSV threshold
        - Thresholding the colors representing the reflected light allows us to obtain a binary image, making it easy to see areas with the correct lighting
      - 4-sided convex hull
        - Finds a polygon that represents the goal and focuses on everything shaped like the goal
      - Fullness
        - Checks how full the picture is of thresholded pictures to eliminate targets with too much or too little light
      - Aspect ratio
        - Checks to make sure the target has about the right dimensions
      - Skew
        - Checks to make sure the target is orientated correctly
      - Start with all the pixels in the image and eliminate everything but the goal
    - Target coordinates are sent to the RoboRIO over a USB interface

PROGRAMMING chezy vision 2.0



- RoboRIO targeting system calculates the coordinates of the goal:
  - From the camera lens, a virtual ray (or line) projects the pixel representing the center of the goal
  - Distance to the goal is calculated by intersecting the virtual ray with the known goal height
  - The image, its timestamp, and history of robot motion determines the position of the camera when the image was taken
  - Bearing is derived using the known camera mounting height and angle
  - Measurements are tracked and smoothed over a short time horizon
- Included in calculations are turret angle, hood angle, and flywheel speed
  - Turret angle is found by determining the angle between the current turret center and the bearing towards the goal
  - Hood angle is found by using measured range as a key
  - Flywheel speed is constant, we found a compromise between shot consistency and range
    - Made from a variety of positions
    - Less power - more consistency but less range
  - This key is interpolated into a lookup table generated from manual shots

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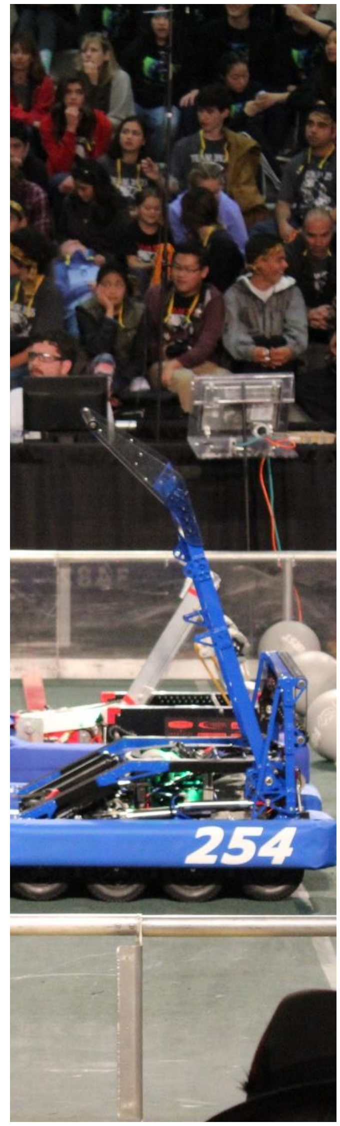
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