LOCKDOWN

254

2018
Technical Binder

TABLE OF CONTENTS
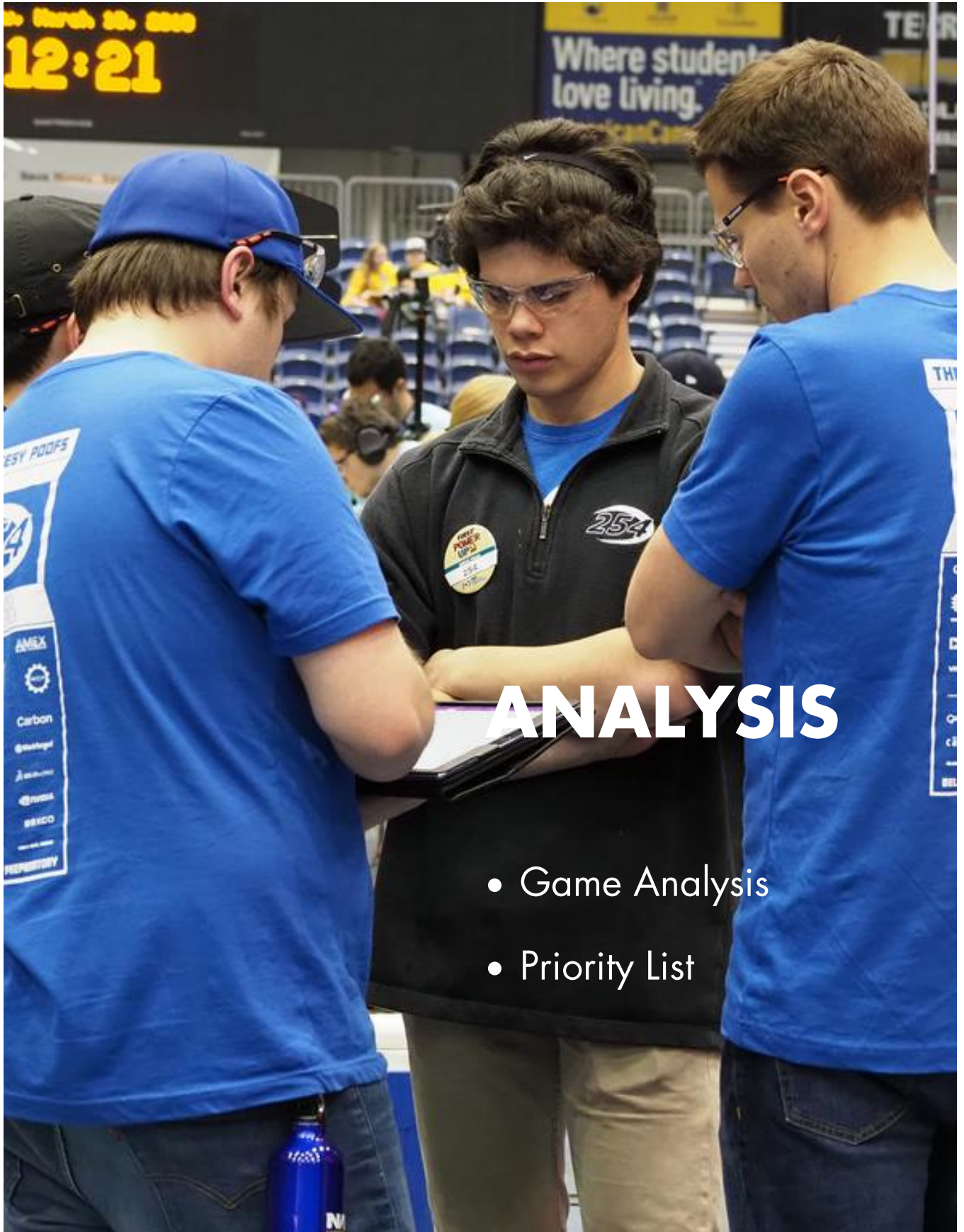
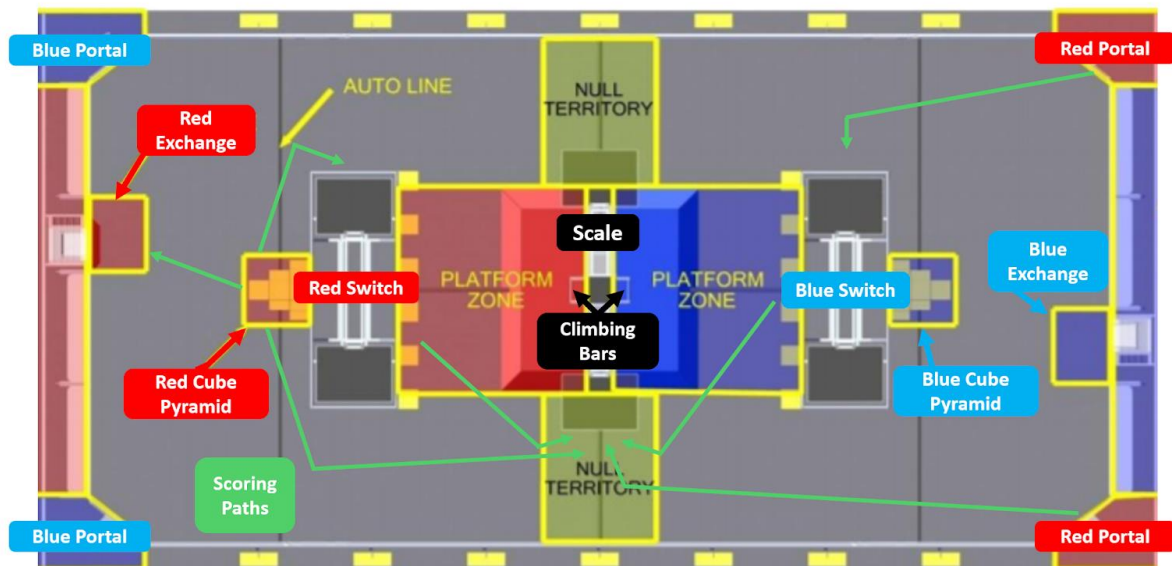# ANALYSIS

- Game Analysis

- Priority List

Game Analysis

This year's game involves a strategy that succeeds in performing all tasks presented in the Challenge. The major tasks associated with this year's Challenge are grabbing, lifting, and placing cubes onto large balancing scales and small switches to tilt them in your alliance's favor to score points every second. Power-ups, scored with cubes fed through the Exchanges, can also be used to score points by forcing ownership or doubling points from the switch and/or scale, or "Levitating" a robot for a free climb (30pts).

With the objective of winning the world championship in mind, our first goal was to seed first, by maximizing our ranking points score, to pick the best possible alliance. However, to not rely on our alliance partners, meant that we'd need to lift ourselves and a partner, while "Levitating" the third. Also, since we were unsure which role we'd play in eliminations, we'd need to excel at the exchange, scale, and switch. Since scoring cubes early meant we could "Get ahead, Stay ahead", we prioritized an ambitious autonomous routine to score 3 or 4 cubes on the scale. To accomplish this and other cycles, we optimized our drivetrain acceleration for short paths(<30 ft) and required the ability to score out of either side of the robot. Thus, the following Priority List illustrates how our game analysis resulted in strategic objectives and thus design requirements for various subsystems on the robot.

ANALYSIS priority list
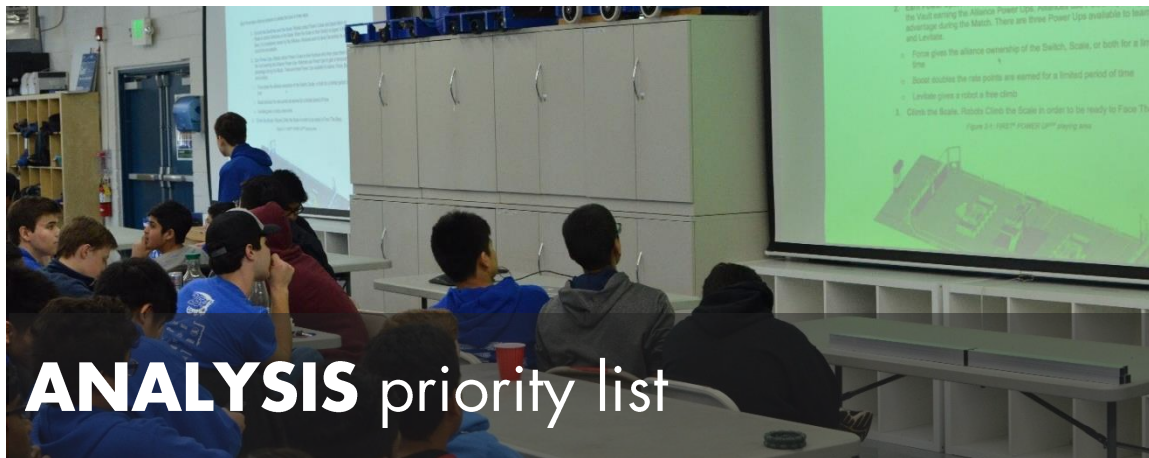
Design Goals:

- Driving
    - Enough acceleration to drive paths for "4 Cubes Near Scale" autonomous routine
    - High precision for accurate robot positioning in long autonomous routine ("3 Cube Far Scale")
    - Never "beach" driving onto platform
    - Enough traction to overcome defense (pins, T-bone)
- Acquisition of Cubes
    - Acquire any oriented cube with minimal driver precision
    - Take individual cubes from the Pyramid without toppling (keep them in protected "Power Cube Zone")
- Scoring Cubes
    - Precisely place cubes onto scale regardless of its position
    - Quickly exhaust cubes to exchange, switch, and scale out of either side
- Climbing
    - Lift ourselves and another partner in less than 5 seconds
    - Hook onto bar with minimal driver precision
    - Ensure any robot can be lifted by us (ex. Easy-to-drive on ramp)

Robot Design Equivalent:

- Drivetrain & Drive Gearbox
    - Quick accelerating low gear to optimize speed
    - Corner omni wheels to help turn smoothly
    - Ground clearance optimized to allow for driving over field obstacles
- Wristed Intake
    - Compression from compliant wheels rapidly centers a cube of any orientation
- Wristed Intake, Elevator & Elevator Gearbox
    - Able to place quickly ("shoot") or precisely ("drop")
    - Wrist permits scoring (exhausting) from front and back of robot
    - Fast traversal to maximum height in high gear
    - High torque to lift ourselves and a partner quickly
- Hanger & Forklift
    - Able to do a solo or partner hang off the box tubing while keeping our CG aligned below the hanging bar
    - Partners need ~0.625" ground clearance to mount
    - Gaps between tines allow robots to "get caught" to prevent rolling off
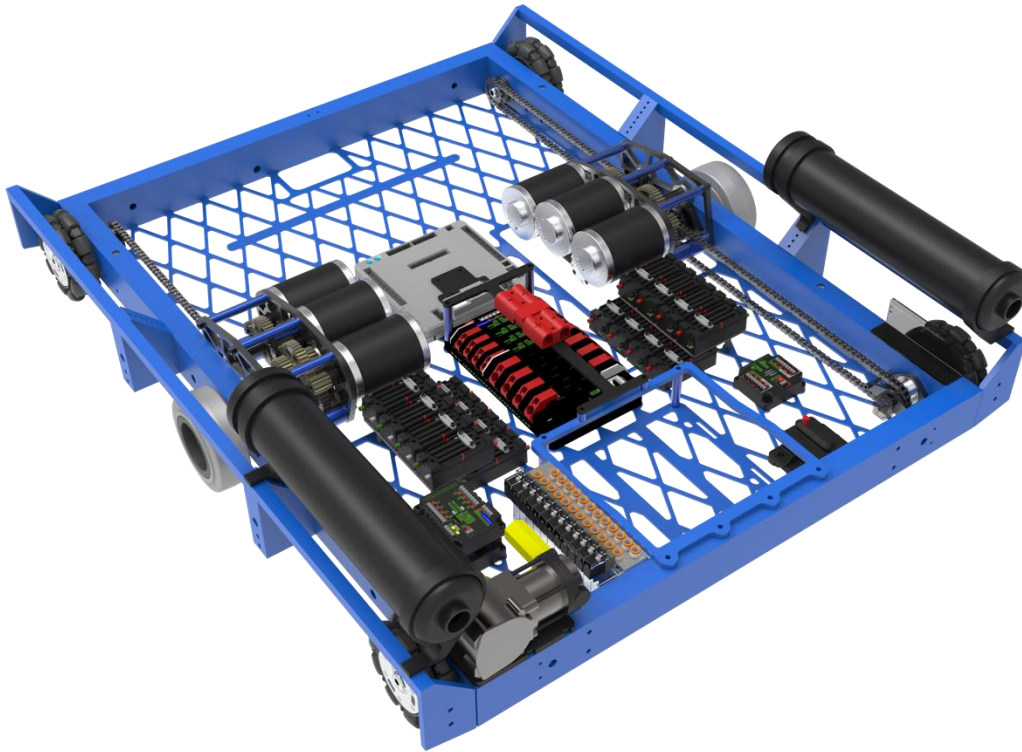
LOCKDOWN
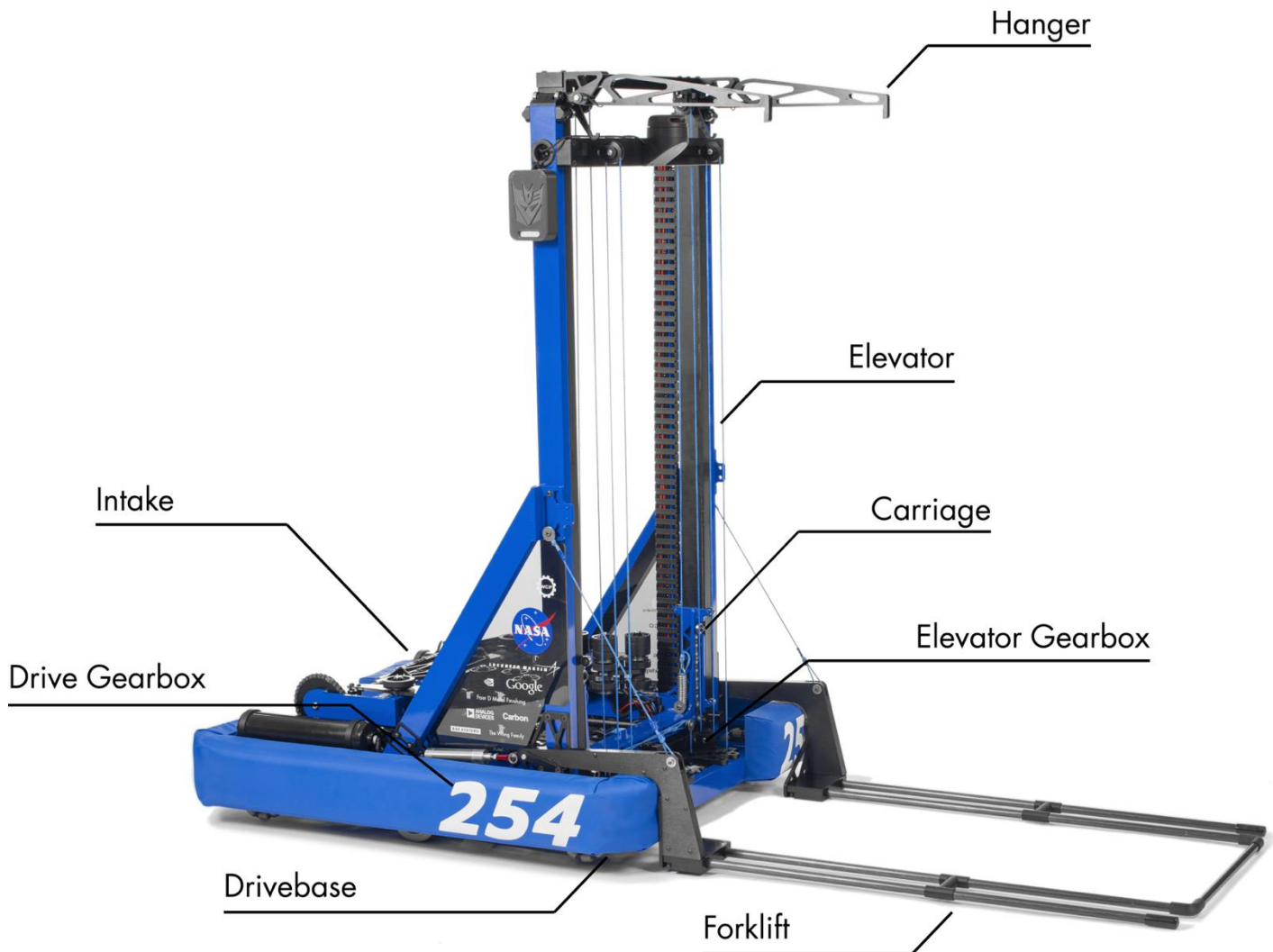
Hanger

Elevator

Intake

Carriage

Drive Gearbox

Elevator Gearbox

254

Drivebase

Forklift

DESIGN

- Drivetrain

- Drive Gearbox

- Elevator

- Elevator Gearbox

- Intake & Carriage

- Hanger

- Forklift

Drivetrain

- Design Constraints
    - Wide wheel base to counteract high center of gravity
    - Sprint quickly in short bursts on the field
    - Drive up platform without high centering
    - Support the load of a lifted robot
- Chassis
    - West Coast Drive
        - 1/8" center drop and 17.75" wheel spacing
        - 2 x 4" Blue Nitrile Traction wheels to grip floor
        - 4 x 4" Omni Wheels to help with maneuverability
    - Bumpers
        - Two piece bumpers with locating pins on left/right side and securing thumbscrews on front/back

Drive Gearbox
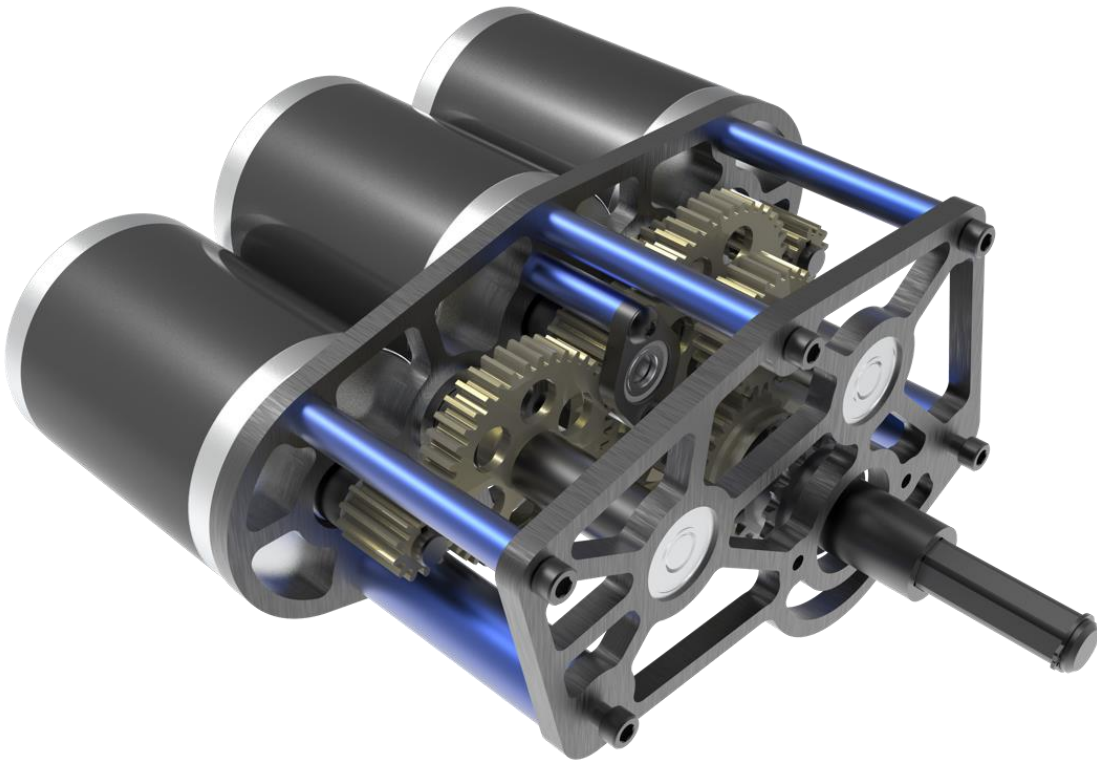
- Design Constraints
    - Low profile to allow intake to rest as low as possible
    - High torque for immediate acceleration in short sprints
    - High top speed for rapid cycles across the field
- 3 Mini CIM gearbox with dog shifter to toggle between two speeds
    - Low – 7.33:1 - 13.89 ft/s
    - High - 5.56:1 -18.34 ft/s
- Flat Configuration Packaging
    - Motors in line to reduce overall height of gearbox
    - Bearing plate on middle Mini CIM shaft allows pinion to not be cantilevered and counteract the rotational forces from other 2 motors

Elevator

- Design Constraints
  - Reaches max robot height when stowed
  - Wide enough to allow a cube to pass through
  - Support torsional forces of lifting 2 robots
- Continuous Cable Rigging
  - Pull up and pull down runs of 1/8" Dyneema rope on both sides
  - Spring tensioning on pull up runs to account for changing fleet angle
  - Distance between pull up runs is 15" to allow cubes to pass through
- Bearings
  - ¾" OD ¼" ID bearings used to react against inner and side faces of stages' tubes
  - Bearings spaced out to contact edge of tubes
  - Static load capacity is large enough to resolve thrust forces from lifting 2 robots

Elevator Gearbox

- Design Constraints
    - Able to stall motors under applied load with minimum voltage
    - High gear to traverse full elevator height in less than 0.75s
    - Low gear to lift weight of 2 robots in less than 3s
    - Low profile to allow intake to rest as low as possible
- 4 775 pro gearbox with dog shifter
    - Low – 42.44:1 – 3.36ft/s
    - High – 12.06:1 – 11.83ft/s
- SRX Mag Encoder on the shifter shaft to accurately track revolutions
    - Wired to REV Limit Switch on the outer stage elevator to detect bottom of travel
- Spools
    - 2 1.75" OD 1/8" thick aluminum spools with 2 cable runs (pull up run and pull down run)
    - Synchronized cable wrapping

Wristed Intake
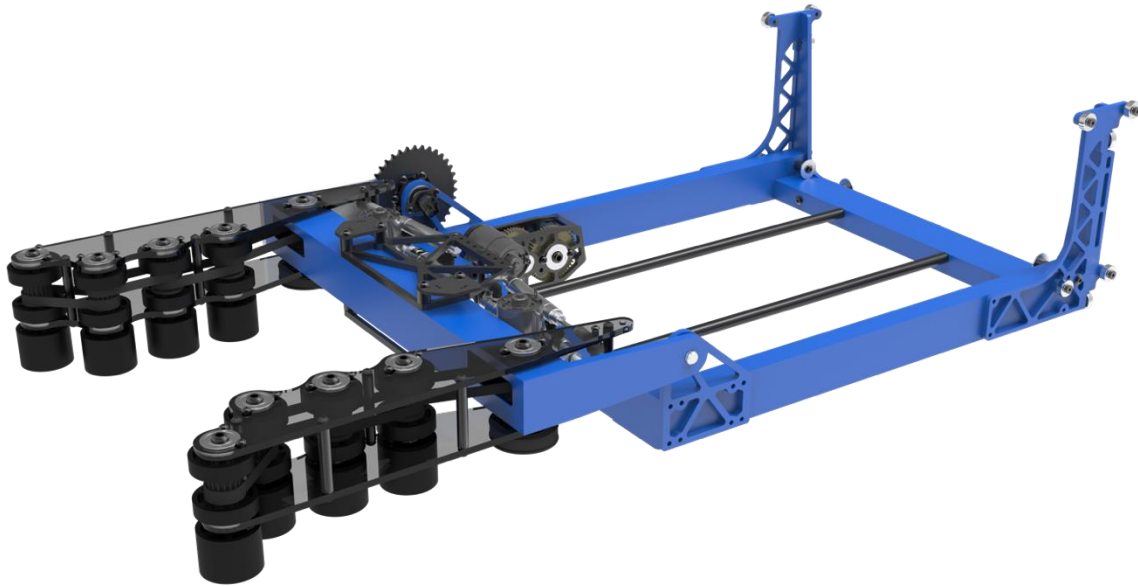
- Design constraints
  - Rapidly center a 13" or 11" cube
  - Tightly clamp the cube when pivoting
- Cube Intake
  - ¼" polycarbonate plates to withstand bending loads
  - 2 775 Pros with a 5:1 reduction
  - 4 sets of 2" WCP Compliant wheels per side, surface speed of 32 ft/s
- Back End:
  - Driven by #35 chain with adjustable CAM tensioner
  - 1 775 Pro with a 150:1 reduction
  - SRX Magnetic Encoder on pivot shaft to detect wrist angle
  - REV Magnetic Limit Switch to zero wrist position when stowed
- Welded aluminum ¼" plates and 2"x1"x1/16" tubes
- REV Magnetic Limit Switch mounted on the back to zero elevator position

Hanger

- Design Constraints

    - Support the weight of 2 robots

    - Stow within frame perimeter and pivot out back

    - Center CG below the hanging bar

- Spring Loaded Hook Deployment

    - Hook stowed in place by air extended piston

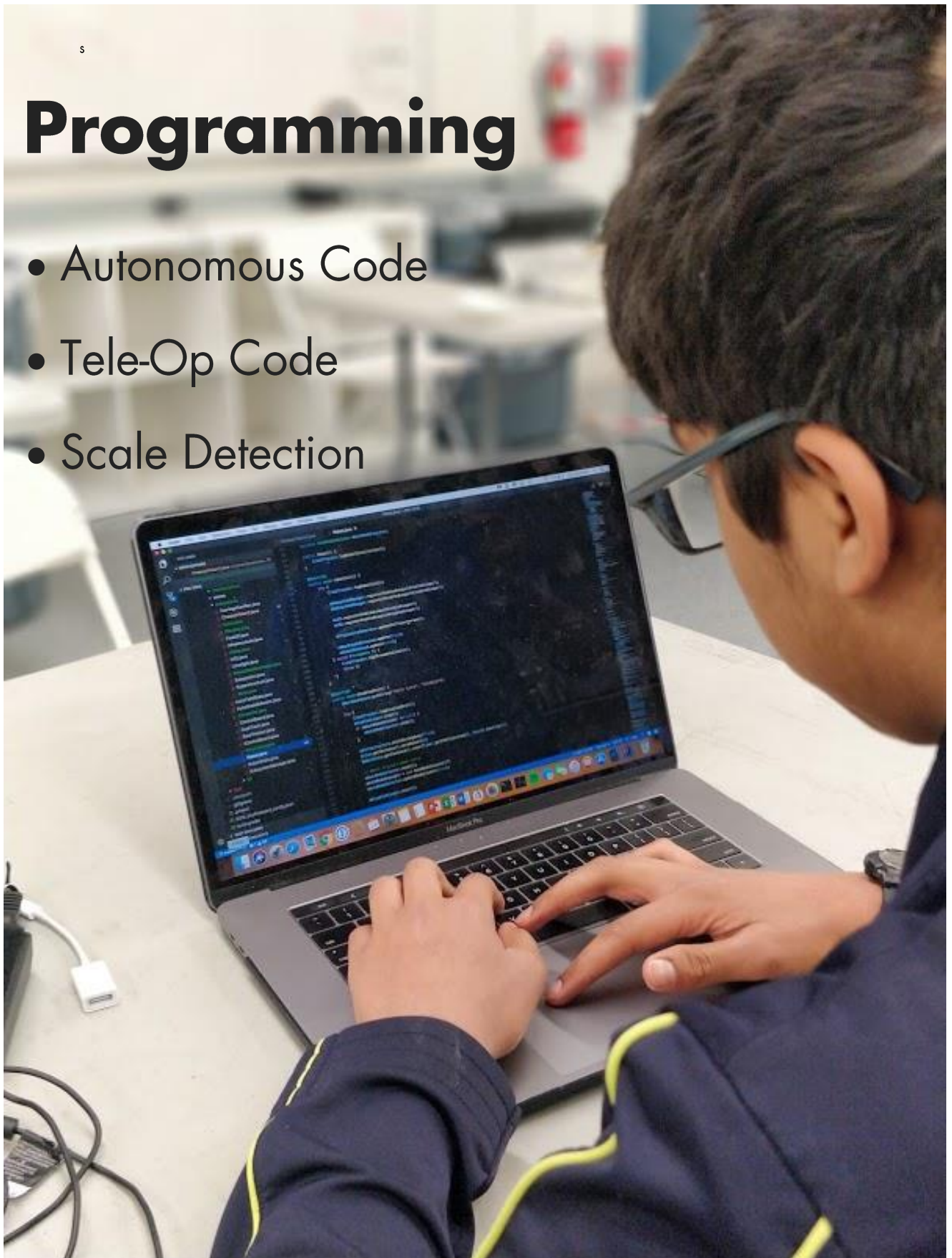   - Hook pivots up until it hardstops against pocketed block
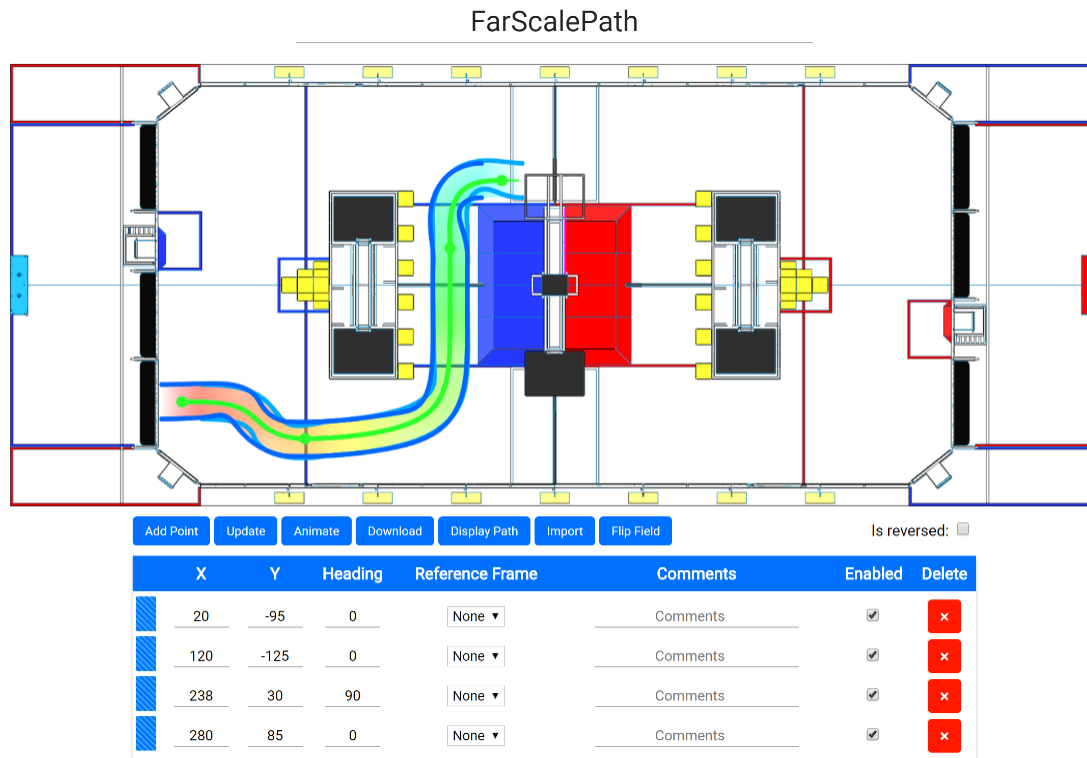
Forklift

- Design Constraints
    - Support the weight of a robot
    - Easily traversible by different drivetrains
    - React against robot bumpers and tensile member to elevator uprights
    - Lightweight and stiff in desired low-height form factor
    - Forks spaced out for a 13″ wide cube to pass through
- Forks
    - Two sets of $^5/_8$″ OD carbon fiber rods
- Pneumatic Actuations
    - Stowed and deployed by 2 pistons protected by bumper
    - Prevented from accidentally deploying during quick accelerations by pancake pistons attached to A-Frame

s

Programming

- Autonomous Code

- Tele-Op Code

- Scale Detection

Autonomous Code

FarScalePath

| X	Y	Heading	Reference Frame	Comments	Enabled	Delete
20	-95	0	None ▾	Comments	☑	×
120	-125	0	None ▾	Comments	☑	×
238	30	90	None ▾	Comments	☑	×
280	85	0	None ▾	Comments	☑	×

- Path Generation
    - Path Generation using parametric Quintic Hermite splines + web-based visualizer for spline creation
    - Runs an optimization function to minimize the change in curvature over the spline
    - Results in better paths and better tracking
- Driving Controller
    - Uses a pure pursuit controller to control steering along the spline
    - Advanced feedforward command generation that accounts for some intrinsic parameters calculated for modeling motors

18

Tele-Op Code

```
53    /**
54     * Gives the RigidTransform2d.Delta that the robot should take to follow the path
55     *
56     * @param pose
57     *           robot pose
58     * @return movement command for the robot to follow
59     */
60    public Command update(RigidTransform2d pose) {
61        if (mReversed) {
62            pose = new RigidTransform2d(pose.getTranslation(),
63                    pose.getRotation().rotateBy(Rotation2d.fromRadians(Math.PI)));
64        }
65
66        final Path.TargetPointReport report = mPath.getTargetPoint(pose.getTranslation(), mLookahead);
67        if (isFinished()) {
68            // Stop.
69            return new Command(Twist2d.identity(), report.closest_point_distance, report.max_speed, 0.0,
70                    report.lookahead_point, report.remaining_path_distance);
71        }
72
73        final Arc arc = new Arc(pose, report.lookahead_point);
74        double scale_factor = 1.0;
75        // Ensure we don't overshoot the end of the path (once the lookahead speed drops to zero).
76        if (report.lookahead_point_speed < 1E-6 && report.remaining_path_distance < arc.length) {
77            scale_factor = Math.max(0.0, report.remaining_path_distance / arc.length);
78            mAtEndOfPath = true;
79        } else {
80            mAtEndOfPath = false;
```

- Tele-Op Code
  - Several safety checks that prevent collisions in superstructure
  - Superstructure Motion Planner to coordinate wrist, elevator, and intake
- Superstructure Motion Planner
  - Observes the current state of wrist, intake and elevator and takes in a commanded state
  - Calculates a safe and efficient way to transition from current state to commanded state
  - Coordinates movements between the wrist, elevator, and intake
- Dynamic Feedforward Calculation
  - Improves the control of wrist and elevator
  - 2 main components: Gravity and Acceleration Compensation
    - Gravity Compensation used to oppose the force of gravity acting on the wrist and elevator to make both systems more linear
    - Acceleration Compensation is used to improve the control on the wrist when elevator is moving
      - Acceleration of the elevator exerts a downwards or upwards force on the wrist, so uses a feedforward term to oppose this force

Scale Detection
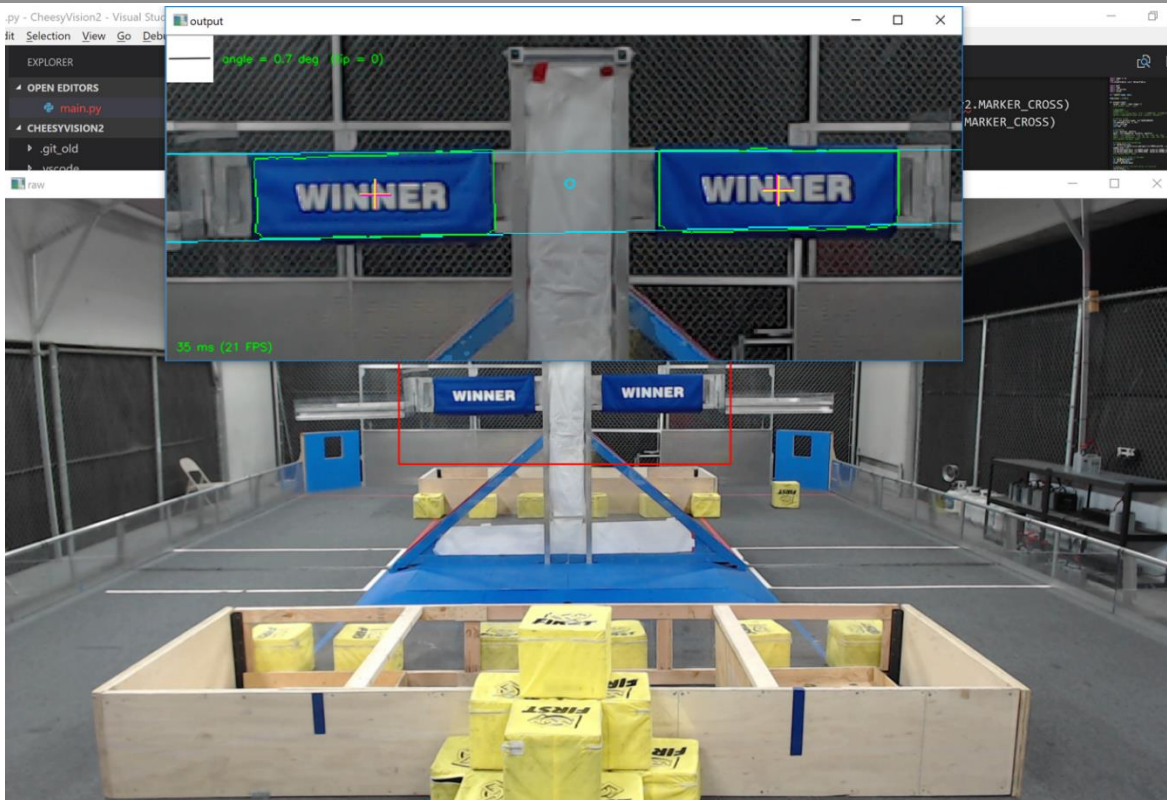
- Scale Detection
  - Finds if scale is tipped in order to raise elevator to correct height
  - Uses a webcam on the driver station to track the angle of the scale
  - Using OpenCV and Python, the purple arm is tracked in each frame and the angle is computed using several different methods
  - All this angle information is stabilized and combined into a single reading of the current angle of the scale
  - The result is a very robust system for automatically (during either auton or teleop) determining what height to raise the elevator to in real time