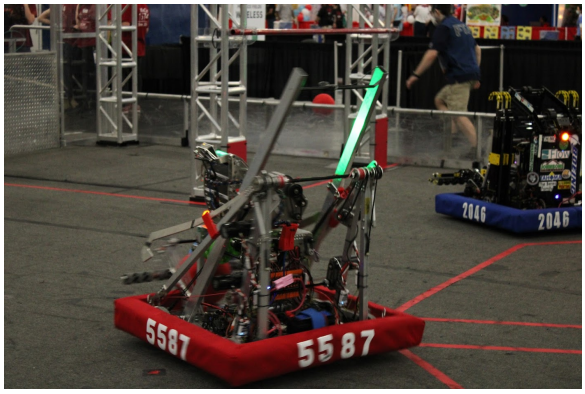
# TEAM 5587 - TITAN ROBOTICS

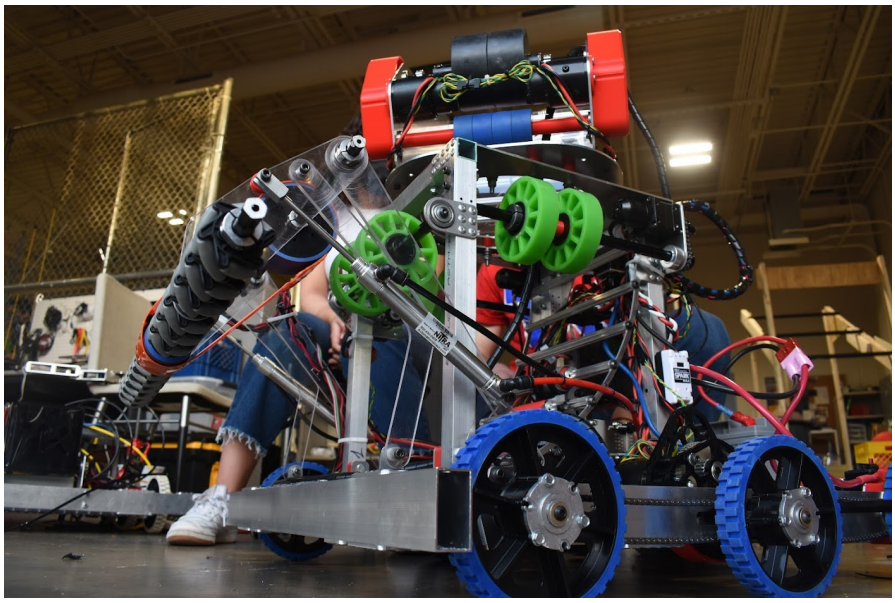
# ENGINEERING NOTEBOOK

## Rapid React

## 2022 Season

PRESENTED BY BOEING

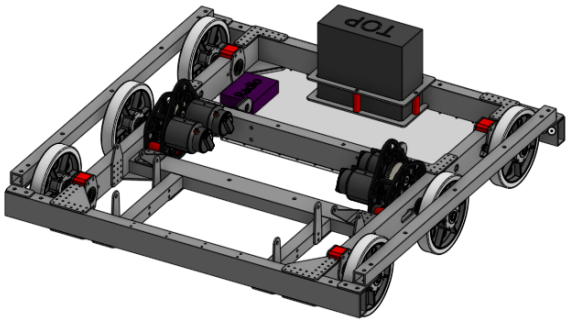


# Robot Specs

## Drivetrain:

- Built a West Coast drivetrain with 4 falcons and a 54:20 Gearbox.
    - This gear ratio was picked due to the high torque offering high defense capability. Additionally, using the falcons increased the torque as well as higher wire management due to the integrated motor controllers.
    - Designed custom Versa-blocks to tension chain.
    - Used 6” thread changeable wheels to allow the highest torque at all times.




**Pros:**

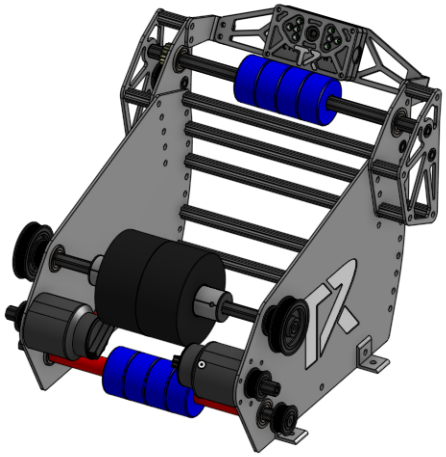
- Allowed us to push other robots very heavily and play very good defense.
- Made it harder for other robots to play defense against us.
- Very minimal problems during the competition, quite reliable.

**Cons:**

- Lower mobility than swerve modules. Making it harder to move around other robots at times.
- 25# chain kept breaking, this problem was solved by changing to 35# chain.
    - The 35# chain couldn’t be completely tensioned at all times since tensioning mechanism was built for 25# originally. No other problems.

## Shooter (+ Turret):

- Used 4” rubber wheels for high traction and torque. Also used 2” in the back of the shooter to cancel out any backlash. The shooter was placed on a custom bearing to allow the robot to shoot into the goal without rotating the whole robot. This gave the shooter 180 degrees of rotation.



**Pros:**

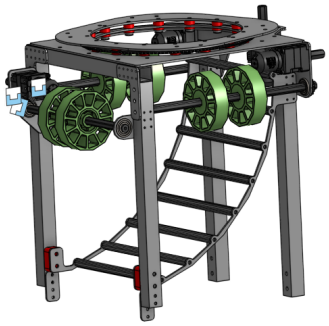
- The turret played a big role in shooting efficiently even when other teams were playing defense.
- Limelight tracking was very useful because the robot was ready to shoot at any time.
- The 2 falcons played a big factor in getting the shooter running fast very quickly which helped increase cycle times.

**Cons:**

- Slower than planned cycle times due to the shooter not being adjustable, this is something we knew but didn't want to tackle due to its difficulty. This decreased where we could shoot from.
- The turret fell off a couplet of times during the competition, this could be fixed by increasing the surface area of the bearings.
- The wires limited the degrees of motion, this could be fixed with better wire management (this wasn't a big problem).

## Conveyor:

- The conveyor used 6 compliant wheels to guide the ball from the intake to the shooter, the conveyor also had a “kicker” mechanism that used line break sensors to check when there was a ball in the conveyor so the drivers knew when to shoot.



**Pros:**

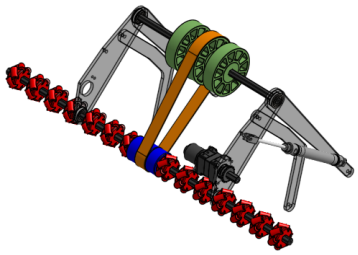
- Very reliable and didn't break at all.

**Cons:**

- Had to increase the compression but that was done very easily and quickly.

## Intake

- The intake used Mechanums to filter the balls in the robot and a belt attached to a 2” stealth wheel and 4” compliant wheels to guide it into the robot.



**Pros:**

- Using polycarbonate sides and low-pressure pistons made the intake very retractable and flexible. This made it so it never broke during competition no matter how hard it was hit.

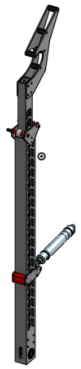
**Cons:**

- Slightly difficult to build.

## Climb

(V1)

- The First climb built was made to hook on to each rung and climb up with four arms. (2 for each rung). It was mounted with pistons to keep the rotation to 2 angles.

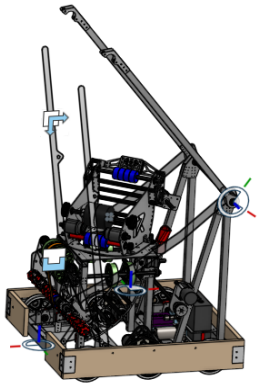


- **Pros:**
    - It kind of worked.
- **Cons**
    - It climbed very slowly and inconsistently.
    - Had very specific and hard-to-build mechanisms.
    - Very high friction.
    - Difficult to build and fix due to all the rope being internally channeled.

## Climb

(V2)

- This climb was a quick build since the previous climb mechanism didn't work. The new one skipped the middle rung which increased the climb time.



- **Pros:**
    - It worked really quickly and efficiently which helped out a lot.
    - Quick turnaround.

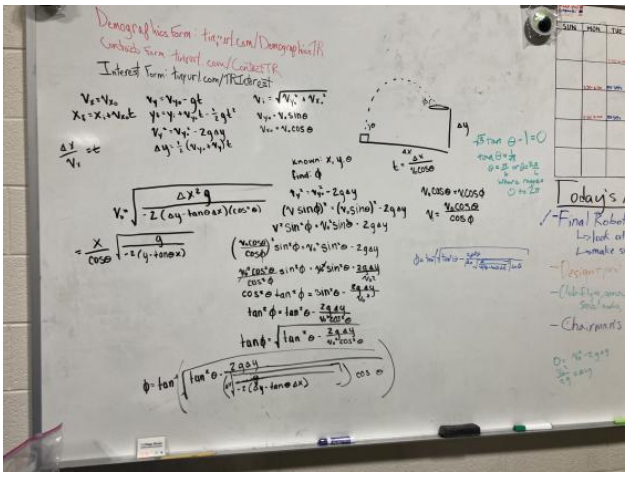
- **Cons:**
    - Required a lot of driver training since it wasn't autonomous.
    - (small problem), it took too much space when climbing to the top rung which slowed down other alliance robots.

## Week 1

**1/11**

*Design:*

- decided on a cut-out west coast drivetrain with a hooded shooter and a turret. Discussed placement of mechanisms and electrical board.
- .5”-1” compression works the best, started to prototype a new roller with 2” stealth wheels in the middle and omnis on the side. The same level of compression (~1in) seemed to work best. Next meeting, we need to space out the omni wheels (probably using 1/2in spacer in between each one). The stealth wheels may need to be spaced out but not as decided. The goal for the next meeting is to see whether this centering method would be viable and see how much the intake can kick back the balls.
- started on the physics to figure out the correct angle for the shooter. however, we ran into an issue where the equations we were mathematically getting weren't fitting logical conclusions




**1/12**

*Manufacturing:*

- Attempted to machine one "hand" of the climber in order to test its effectiveness. However, we ran into some issues (still unknown) and mach3 crashed, after finishing the bores but before the contours. Tomorrow we will resume, and ideally, finish
- Churros for the climber hand prototype are cut and tapped.

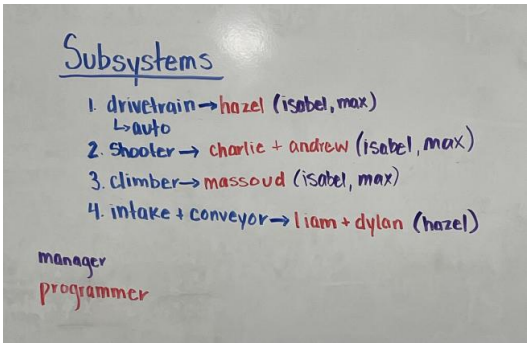
*Design:*

- For the beginning of a prototype of the conveyor, we assembled the pulleys for a few of the belts and began forming the 80/20 structure. We are planning to test what will happen when the belts are pulled from the sides. In order to have enough brackets, we scavenged from bob's shooter and conveyor system. Next meeting, we need to build another side to the contraption so that compression and effectiveness can be tested, and the current side needs to be finished built. A conveyor design that runs from above/below would also be interesting to design/test

**1/13**

*Programming:*

- Today we made the new GitHub repository compatible with WPILib's 2022.1.1 Kickoff release. This mainly involved changing imports that have moved package locations, along with using newer, non-deprecated packages such as MotorController. We also created a delegation system and a plan for the completion of all of the subsystems that will be on our robot. Here's what we wrote:




*Design/Manufacturing:*

- Fully manufactured hand, broke several endmills in the process of finding better feeds/speeds but determined that a 0.0025" feed per tooth and 0.024" depth of cut provided more accurate parts without sacrificing very much speed. The hand was also fully assembled and tested. It proved it could hold a 94 lb load, but was not able to hold myself (140 lb), this is Plenty of loads given that two of these will be holding the robot. It failed when the bar forced the jaws open, with no catastrophic failure.

https://photos.app.goo.gl/j22Lec7ymULssD3K9

- Today we began creating a hooded shooter prototype to determine the best compression. We created an 80-20 frame to hold the spinning hex shaft with four 4” Colson wheels on it. We placed it up against a flipped-over table and tested it with a drill. It proved difficult to stabilize the frame and motor when the ball was being shot through, which will have to be resolved tomorrow. We upgraded to a neo because the drill wasn’t spinning fast enough.

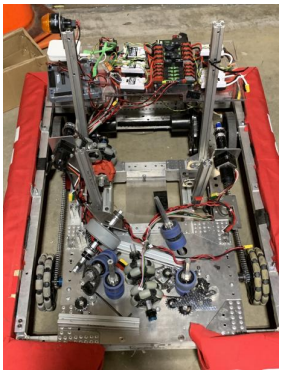
*Design (Conveyor Prototype):*

- Today we built two identical 80-20 frames to hold up the hex shafts that held the pulley. The pulleys were lowered so that the tensioned tread would meet the ball right around the middle. We tested this on high and low power with the drills, and they both worked well.

**1/14**

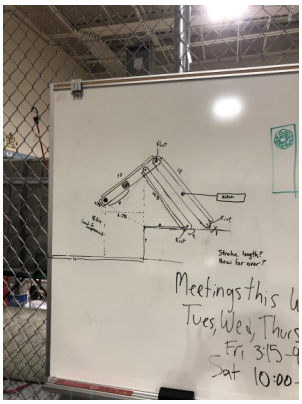
*Side projects:*

- Started stripping bob for parts. Got the shooter off and just need to take apart motor wiring and housings. Plan to re-use parts for new robot:



*Design (Intake):*

- Began figuring out the design for the four-bar intake. Created a mini-concept version to explain and test the idea:



*Design (Claw mechanism):*

- Continued testing of the arm design, discovered it needs to be within 9.5 degrees of the bar to clamp. Also requires the hook to be above the halfway mark to clamp./ Started to make a cad with the arm rotated by 30 degrees to eliminate the weight limitation of the arm.

*Design(Turret Prototype):*

- Built the idea the turret group developed before by creating a wooden circle with bearings on the perimeter. It was difficult to align the bearings so the end result was a bit sketchy and didn't work as well as it could have. On the bright side, it did spin with less friction than flat on the table.

*Manufacturing:*

- Made the lower stage of the arm, due to routing issues, the step-downs were lowered to .002" to fix the problem. There was mild inaccuracy from the machine's acceleration.

# Week 2

**1/17**

*Manufacturing:*

- Routed some brackets for the arm. Also found better feeds, speeds, and doc; 51 rpm, with 0.024" depth of cut. Sacrificed many endmills to get the best feeds and speeds, and also found tolerances of between 0.08-0.01 to things like bearings and hex shafts.

*Side Projects:*

- Continued recycling Bob for parts removed electronics to be used in future projects.

*Game Elements:*

- We designed the wooden structure for the hangar. We had the needed 2x4s and plywood, and we received wood to create a game element. We have a general plan in place. The pieces made include the pipes (split into 3 pieces). One 2x6 was prepared, and the 2 right triangles were cut out. Next time we work on this, we need to make the second 2x6, and prepare the 2x4s (especially the cross brace on the back). We also need to obtain the correct-sized nails and the clamps for the pipes.

*Awards*

- Today we finalized the writing outline for the Chairman's award presentation. We then started making a general draft of graphics and photos we'll use for the presentation itself, including photos representing virtual outreach, volunteer work, team growth, new environments, demographics, and so on.

**1/18**

*Design (Prototyping):*

- We designed and began to prototype an extension for the intake. It uses two of the rollers we made last week. Next meeting it needs to be mounted on Bob's drivetrain and we need to test how we are going to extend and retract the intake.

*Manufacturing:*

- Added a few holes to the outer arm bar, finished routing the brackets for the arm, and started routing the inner arm bar. Only broke 1 (maybe 2 end mills ), Found the perfect depth of cut is 0.024".

**1/21**

*Design(Intake):*

- Attempted to cad a 4bar intake but couldn't get the roller not to hit the turret.
- Designed a ball debouncer and began testing different materials. Most likely to go with 1/16 Lexan

**1/22**

Design (Conveyor Prototype):

- Re-assembled the conveyor with blue 2" wheels and belts. We still need to test to see if the balls can be lifted with the new wheels and belts.

## Week 3

**1/25**

*Design (Prototype elevator):*

- fully assembled prototype elevator and tested it. Ran into multiple issues with the spacer cracking and bolts getting jammed, but that should just be a product of the nature of the prototype. The elevator was shown to lift at least 65 pounds, we were unable to test higher due to time constraints, however, it didn't look close to failure at all

*Manufacturing:*

- Routed the pieces of the intake out of 1/4 Lexan. Increased the fee- rate while routing pretty substantially, so in the future, we should be able to route faster

**1/26**

*Manufacturing:*

- The cam for the drivetrain brackets is complete and the router is zeroed to a relatively good position. Minimal checking of the zeros will be necessary before the components are routed tomorrow. Ideally, one person is routing while another person continues to CAM.

*Design Prototype:*

- Tested intake design, discovered that the 3d printed mechanums don't work very well, they just slip against the ball. Also found that between 3/4" and 1" of compression on the intake worked best. Intake also does an awesome job of deploying and retracting to a very compact position.

*Game Element Construction:*

- A design was created for the upper goal and we measured and cut all of the PVC tubing needed to assemble. After a bit of confusion regarding what size pipe and

fitting we had, we were able to use what we already had to build the structure. Purchased PEX tubing to create the circle frame.

**1/27**

*Manufacturing:*

- completely machined a custom sprocket!


**1/28**

*Game element:*

- We created the PEX ring for the top of the upper goal and affixed it with duct tape. In the future, we plan on getting the correct connectors so it is more continuous. After the ring was up, we designed a clip to put the retro-reflective tape on so that it is the correct distance away from the hoop. That will be 3d printed, and tested, and if it works, we will print 15 more to clip around the circle.

*Manufacturing:*

- Today we finished routing the drivetrain brackets, the shooter gear, and most of a side rail.

**1/29**

*Manufacturing:*

- Routed the other side rail, the back rail, the updated intake, and the turret base is ready to be routed first thing on Tuesday. Big problems were the flatness of the router, but the bottom right corner seems to be the best.

*Assembly (Rainmaker)*

- removed all 6 falcons from Rainmaker. Put together both of the gearboxes for side rails and broke the chain to the right size. Next meeting, The goal is to finish the side rails by mounting wheels and spacers.

## Week 4

**2/2**

*Manufacturing:*

- Routed the turret base and mounting plate.
- Played around with the bending break, and learned that 6061-T6 aluminum is not ideal for bending. 5051 is ideal, however, 6061-T4 can be bent and then annealed afterward. However, we were able to figure out how to bend 6061-T6 without breaking it by doing two smaller bends before and after the main bend, essentially enlarging the bend radius.

**2/4**

*Manufacturing:*

- Routed turret, shooter, and the rest of the drivetrain (excluding the piece we are waiting on). Found that 19000 rpm at 64 ipm gave us some very nice cuts. In addition, we had this very weird problem where whenever we tried to route old stock, both square tube and sheet, it would gum up the endmill really bad. Don't know whether this was a result of a different alloy/temper of aluminum or just aging it. We also tested the shooter and determined it needed another .5" of compression. We tested the conveyor and determined it needed a 10:1 reduction on the drive motor, bringing the total reduction 90:1. At this speed it was very strong, and could spin very fast—several times a second (unloaded).

*Intake testing:*

- Tried to test the intake but messed up the shaft in the baby neo. The motor is now replaced, so the intake just needs to be reassembled and tested with mechanisms.

*Assembly:*

- Almost finished the drivetrain assembly. Need to mount the front rail, bumper rail, and wheels. Attached is the conveyor structure to the drivetrain.

## Week 5

**2/8**

*Assembly:*

- Taught versa planetary gearbox info, made 2,10:1 gearboxes, and fixed the neo with the busted encoder wire.
- Tested the shooter compression, and it worked quite well, still needed to test with a motor(compression was 1"). Started attaching the turret top to the shooter. Cut the chain and started mounting motors for the conveyor.

*Manufacturing:*

- Routed shooter sides, intake brackets, and back elevator mounting brackets, all went well.

**2/10**

*Assembly:*

- We worked on many aspects of the robot, with varying degrees of success. The turret's chain was difficult to attach but by walking the motor mount holes we were able to make it work. Once we overcame some difficulties with running the motor, we proved that the concept works really well! The one problem we had was with the motor sprocket and the turret sprocket not being level. We are going to resolve this by adding extra spacers to balance things out so we took the turret off the robot. We worked on mounting the intake as well and have to make sure that the wheel spacing matches the CAD because it doesn't seem to work in its current configuration. We also need to add a spacer to where the piston attaches to the intake because we discovered that it hits and doesn't fully retract. Most of the chains connecting the conveyor and intake were completed with the hopes that we will be able to test them soon!

*Manufacturing:*

- We ran into the issue with the unstoppable estop while routing the conveyor Lexan, so we were only able to route a sprocket. for future incidences, we should check the estop connection to the router computer. next meeting, we need to tape up the brown wire on the zeroing plate, and we should also look into resoldering that wire.

**2/11**

*Manufacturing:*

- New router problem: the zeroing plate triggers the estop but most of the limit switches don't. Current fixes are keeping soft limits on and zeroing by hand.

*Assembly:*

- Max M and I got the longer bolts for the turret and mounted them on to the robot. After some motor controller problems, the turret spun smoothly. The chains connecting the conveyor to the motors were completed and the belt connecting the shooter was also added. We began power poles for the new falcons on the robot, starting with the shooter. The intake was partially reassembled and next meeting we need to put the last bar in with the new spacers. We had to add some extra spacers between the end of the piston and the Lexan so that the intake would retract, which seemed to resolve the issue.

**2/12**

*Manufacturing:*

- Manufactured Piston mounting brackets for 2 climbers. Started routing square tubes for the climb, but only finished 1 side successfully. The soft limits on the router mess up the zero for the square tube, it is sketchy but turning soft limits off seems to fix the issue.

*Assembly:*

- Mounted battery mount. Spaced out(more) piston for intake since it was hitting intake sides. ~30 psi is enough to get the intake in and out, 40 should be the maximum. Bent brackets for climb rotation that fits on thunderhex but might not lignup with rivet holes. Almost finished intake wheels. Started cadding/designing electrical board. Added drivetrain wheels.

# Week 6

**2/16**

*Manufacturing:*

- Continued manufacturing brackets for the robot.

*Assembly:*

- Fixed intake. Redid chains on the other spots, turns out the looseness was due to using a master-link. It is perfectly tensioned with the original chain.

**2/17**

*Electrical:*

- We mounted all motor controllers and began connecting them to the pdp. We are almost finished mounting the compressor and the wires on the solenoids are almost done being taxed so that those can be connected too. Tomorrow we will finish up what we started today and hopefully finish the electrical board and pneumatics!

**2/18**

*Assembly:*

- Mounted limelight (and bent bracket successfully!), flipped front rail, attached new wheels, redid chains within the conveyor and kicker, finished assembling the shooter, and attached the conveyer Lexan. We devised a fix for the dead-spot involving 3d printed cylinders on the conveyor churros.

*Electrical:*

- We finished mounting the compressor and tining the wires on the solenoids. We are done with CAN and motor controller extensions (I think) after some soldering iron difficulties. Tomorrow we will finish wiring CAN and all of the other wires.

*Manufacturing:*

- Finished the climb bars for half the climb. No router issues beyond what was pre-existing.

**2/19**

*Assembly:*

- Discovered that those conveyor roller extenders worked very well, currently printing 2x .5" and 2x .25" ones to go on the robot. Assembled part of both elevators. Put a 4" stealth wheel on the conveyor instead of compliant wheels. Welded the poly-cord belt for the intake.

# Week 7

**2/21**

*Assembly:*

- Assembled turret with thrust bearings, works perfectly!! Put roller spacer things in the conveyor, one of the small ones was made large with some bolt tape and velcro, and it works great!

*Electrical:*

- Wired can bus, nearly finished wiring pnh, fixed some bad solder jobs, wired intake, and designed a method to wire the turret that would allow it to spin 360 without using any springs!

**2/22**

*Electrical:*

- Finished electrical for everything except turret (and climb). Tried to update the firmware on the spark maxes and there was some difficulty.

**2/23**

*Electrical:*

- Fixed several leaks in the pneumatic system, and wired up the turret.

*Assembly:*

- Halfway assembled one of the climbs and started assembling the other.

*Manufacturing:*

- Figured out that we don't have a good collet for .25 endmills, so we began routing the bumper wood with the .125 endmill.

**2/24**

*Programming:*

- Successfully characterized intake & configured PID! Will continue characterizing the rest of the motors tomorrow.

*Manufacturing:*

- Finished bumper wood, but now it needs to be filed.

*Assembly:*

- We worked on the climb, particularly on building the gearboxes. We ran into some issues because the identical gearboxes seemed to have different torques so we

tried to troubleshoot and settled on the hope that one is over-greased and that spinning it a lot will resolve the issue. On 2/25 we hope to finish assembling the two arms with the brackets we have.

## Week 8

**2/28**

*Programming:*

- Characterization complete for intake, conveyor, kicker, turret. Updated PID values for turret for enhanced accuracy. Started working on commands & command-groups for better control flow. Finished writing base shooter code - was unable to test due to an issue with the falcons that should be able to be resolved on 02/29. Hopefully should also be able to characterize the shooter on 02/29.

*Assembly:*

- Fixed the Elevators, both work very nicely. Was going to start attaching climbers to the robot but the brackets for climb rotation weren't bent correctly(at least one side).

**3/2**

*Bumpers:*

- Determine the best hole size for fitting over the knob thingy, which is a 27/64 bit. Another lesson learned is that if using the clip as a template to drill the rivet holes, the clip has to be open. We also realized that there needs to be one gold washer and two small silver washers under the knob to create the correct spacing. All in all, we got one bracket drilled properly and two more that are halfway done.

*Electrical:*

- wired up limelight with poe, wired 2 climbs, fixed some wiring on the pnh.

**3/4**

*Programming:*

- did a bit of shooter stuff, nothing conclusive, however, we did fully characterize the robot and get paths running accurately in an all-time record (80 mins).

*Manufacturing:*

- Routed one outer tube and most of an inner tube. No real issues, just problems clamping leading to a couple of broken endmills.

**3/7**

*Manufacturing:*

- routed the fourth outer tube, the hooks, and additional climb motor brackets

**3/8**

*Manufacturing:*

- Routed the fourth inner climb tube.

## Week 9

**3/14**

*Assembly:*

- We are almost done switching the drive train from 25 chains to 35 chains. The chain breaker was being a little annoying but that was resolved with a trusty hammer and screwdriver combo. All that's left is mounting the wheels with the appropriate spacing so that the robot can be driven until we get the new wheels. The climbs were all removed as well to make this process easier.

*Programming:*

- Replaced intake Spark MAX (intake fully functional again). Implemented current limits onto every subsystem to prevent power surges & faults. Started going through the competition code & cleaning it up to be clean and merged to the main. Began to develop ideas for the programming side of the new climb.

*Design:*

- Did some frame-by-frame analysis of 125's climb, and finally determined that it was feasible to attempt, could maybe be done by our second district comp, but will def be done by dcmp. Determined that the intake will have to deploy to let the arms pass, then retract to let it pull down all the way. Also created a cool sketch demonstrating how it would work

**3/15**

*Manufacturing:*

- Routed the brackets and two of the arms for the new climb.

*Assembly:*

- The blue wheels were attached and then we almost finished angle grinding the corners out of the brackets to make room for the new climb.

**3/16**

*Assembly*

- The turret is fixed! We attached the big washers and it seems to be more secure, but we should definitely check tomorrow. The corner brackets were finished being filed to make room for the new climb. The blue wheels are all off so tomorrow, we can put the new ones on. All the hubs and hardware were put in a cup/bag in the gray prototyping cabinet for future reuse

*Manufacturing:*

- Routed the rest of the new climb square tube, and found the .125 Lexan stock. I picked up the .25 Lexan tonight so we should be able to start manufacturing the sticky arms tomorrow

**3/17**

*Assembly:*

- The new wheels are on! The climbing structure is attached at the expense of two drill extenders. We moved the conveyor motor bracket so it doesn't interfere with the arms. Tomorrow we need to fix the electrical board and finish the climb… and test of course.

*Manufacturing:*

- Routed the hooks for the new climb, as well as the motor mounting brackets. Lexan feed can probably be increased by 30%.

*Bumpers:*

- Re-drilled the brackets on the right blue bumper and confirmed that all the bumpers fit. The bolts on the new wheels didn't clear the bumper bars, so we ground them down. The bumpers are finished!

## Week 10

**3/23**

*Assembly:*

- Today the conveyor was fixed! Then we started working on switching the treads on the wheels. Many of the bolts were stripped or had deformed threads. We also lost 3 of the nuts. As a result, we tried looking to see if we had replacement hardware which took a while to figure out if they were 10/32 or 8/32 hardware. We determined that they are 8/32 bolts with lock nuts. For the time being, we are using the semi-stripped bolts with normal 8/32 nuts. Ideally, we find a better way to shorten bolts that isn't the angle grinder because it deforms the threads and causes many of these issues.

**3/24**

*Electrical:*

- Fixed the Robo-rio, router, and pnh not being wired correctly, added USB camera for the driver, and determined that the breaker sensor board on the pdh was not working correctly because it kept thinking random breakers were tripping.

*Programming:*

- Got pdh on the CAN, the issue was that it had the ID of 9 when it should have had 1. Fixed auto, turns out the commands established in configureButtonBindings(), run during auto so it was canceling the auto commands because LockTurret was self-interfering, solution: remove lock turret from auto commands. Lowkey this is a jank solution because it limits turret mobility during the auto, but we'll figure out a fix later. Also, we got a 2-ball auto consistently working, there are some slight odometry issues, so the 4-ball auto isn't working yet.

*Mechanical:*

- Determined that when the robot is sitting on the back of the drop-center there isn't not enough compression for the intake to work correctly, we'll do a slight redesign to allow for more compression.

## Week 11

**3/28**

*Manufacturing:*

- Routed the bottom piece for the upper hub.

*Programming:*

- Created and tested new paths for an auto that get the balls differently so we can ensure they make it into the intake. Unfortunately, we ran into a problem where the robot overshoots rotation on tight turns, as well as some turret tracking problems.

**3/29**

*Manufacturing:*

- Routed the upper ring of the upper hub. Ran into a problem with an assembly where since the angles aren’t quite right, it doesn’t line up with the circle properly.

*Programming:*

- Tried to change how paths are generated to make the robot go slower around tight turns and spins. We were able to get some consistent results with the first 3 balls in each path. We also completely reworked how the turret targets and moves, so it can better account for the rotation of the entire robot.

**3/30**

*Assembly:*

- We took off all the elastic for the metal stage of the climb and replaced it with the new gas springs! They work significantly better. We also re-roped the passive stage so that it extends 16” outside of the frame. We need to attach the ropes to the metal stage to winch it back in, and then I think we can test it! We are also debating rotating or switching out the treads after driver practice because some are already wearing down.

**3/31**

*Assembly:*

- Fully assembled climb! When testing, we determined that the Lexan backed by a threaded rod was not an effective "stick" arm, as it bent a Lot. We're in the process of swapping them out for the 2x1 "unroutable" aluminum tubes.

**4/1**

*Assembly:*

- worked on the climb. For the new tube sticks, we used the versa blocks from the one climb to attach the rope and elastic. We ended up switching the hardware on it to low-profile 10/32 bolts so that the hooks didn’t get caught. We still need low profile button head 1/4 20 bolts to completely fix that issue. Once that was all roped up, we tried to climb and realized that the Lexan hooks need to be in line with the robot, or else it doesn’t work properly. They are very twisty so we are going to route aluminum versions so they are stronger. The other issue was that the first hooks wouldn’t release. We fixed this by angle grinding the hooks to make them have less contact with the bar so they would release easier. We also discovered a more effective sequence for getting the traversal climb which involves releasing the sticks before the hooks and the final swing (this can be seen in the video).

*Game Elements:*

- Finished attaching all the wood together, but the Lexan is quite difficult. Tomorrow we should prioritize putting vision tape on the new one and fitting it into the PVC, although I want to see if a net pattern of the lexan can be tested on a smaller scale

**4/2**

*Programming:*

- Tuned turret and targeted tracking system, it works flawlessly! Tested and tuned the shooter velocity compensation, also works well, with both of these, we can shoot while moving.