’Snow Problem Robot Technical Walkthrough for FIRST POWER UP

Nicholas Aarestad, Jimmy Donadio, Peter Irvine, Karl Olson

Abstract—We look at the various component subsystems of ’Snow Problem’s 2018 robot, Metis, named for the Greek Titan of good advice. These include the drivetrain, intake, transfer, and shooter, as well as some of the ”extras” that went into making Metis look good.

1 Introduction

To give you a full picture of Metis, we will first discuss our robot’s overall strategy, and then we will look at four component subsystems– the drivetrain, which is responsible for moving the robot around the field, the intake, which brings the POWER CUBES into the robot, the transfer, which moves POWER CUBES from the intake to the shooter, and the shooter, which fires them into the SCALE and SWITCH. We will also discuss three other broad components of our robot– the electronics subsystems, the various things we did to improve the aesthetics of our robot, and our bumpers.

2 ’Snow Problem’s Strategy

We will begin by recapping ’Snow Problem’s overall robot strategy/functionality requirements:

1) Drive (over the bump and up the platform included)
2) Pick up POWER CUBES off of the ground in any orientation
3) Score in the EXCHANGE
4) Score in the SCALE
5) Score in the SWITCH

You will note that we did not priorities climbing at all. This is not because we do not see it as an important part of the game, but because we thought that focusing on scoring the POWER CUBES would be more useful for teams, as we would likely be able to create a more effective scoring system than if we had to devote resources to climbing.

In addition, we would seriously recommend that teams consider taking a similar view of their robot strategy– being able to do 1 or 2 things effectively is almost always a better strategy for a team desiring to do well in competition than attempting to do everything. This game presents a challenge in which ignoring certain aspects to the game allows teams to build much simpler and potentially more effective robots.

3 Subsystems

Metis consists of four subsystems which will be described below. The first is the drivetrain, which is a key part to any robot. Second is our ground intake, which is essential to quickly acquiring and delivering POWER CUBES, as well as scoring them in the EXCHANGE. Third is the transfer, which takes the POWER CUBE from the intake to the shooter. Finally, we have the shooter, which ejects the POWER CUBE from the robot to score in the SWITCH or SCALE.

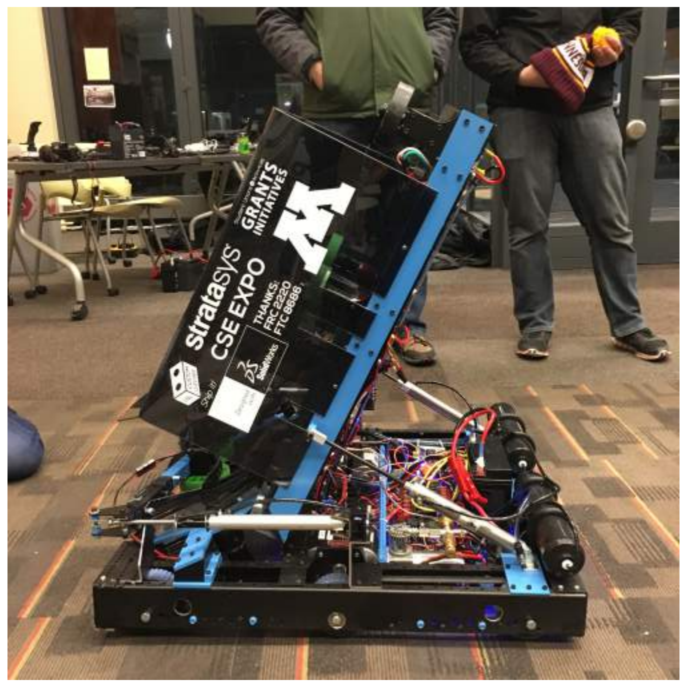

Fig. 1. Metis in its starting configuration

3.1 Drivetrain

The drive train is an essential part of any robot. For any drivetrain, the goal is for it to get you where you want to be, when you want to be there. It cannot do this if it is not working, so we prioritize reliability over all else.

3.1.1 *Concept*

Since our highest priority is reliability and we only have three days to build our robot, we went into the season with the assumption that we would be using the AndyMark Kit of Parts chassis. It is our opinion that the KOP drivetrain is not only incredibly easy to use, but also more reliable and quicker to build than almost any other drive train out there.

3.1.2 Execution

One of the biggest decisions this year is whether you want to go wide, long, or significantly smaller than the frame perimeter. For our purposes, we chose to go with a long orientation as this left us plenty of space for our shooter assembly. With this setup we went with 4″ wheels borrowed from last year's robot, Lelantos, covered in blue nitrile tread. We have a cutout in the front of the robot to provide a location for the cube to enter the robot.

3.1.3 Effectiveness

Our drivetrain was generally successful with out goals– it didn't break at all in our testing, and moved fast enough that we would be satisfied with it in an actual competition. The primary issue with the drivetrain as it is is that the the chassis is too close to the ground, which causes some trouble when attempting to drive up the ramp.

3.1.4 Improvements

Our primary improvement would be to raise the bumpers and frame another inch above the ground in order to easily drive up the platform and over the cable run. This could be accomplished by using 6″ wheels or a custom frame, but we would generally lean towards the 6″ wheels for most teams.

3.2 Intake

Fig. 2. Half of Metis' intake

This year, more than almost any other year, having an effective intake is extremely important at all levels of competition. Being able to quickly intake a crate from an unknown orientation into your robot is valuable to any robot which has chosen to focus on the various aspects of this game related to POWER CUBES.

3.2.1 Concept

The primary concept we had for intakes was to use two continuously rotating wheels to intake the block. We also had a number of other ideas– pneumatically actuating these rollers to get them outside of the frame perimeter and bumpers, and elastically mounting the rollers to accommodate different orientations.

3.2.2 Execution

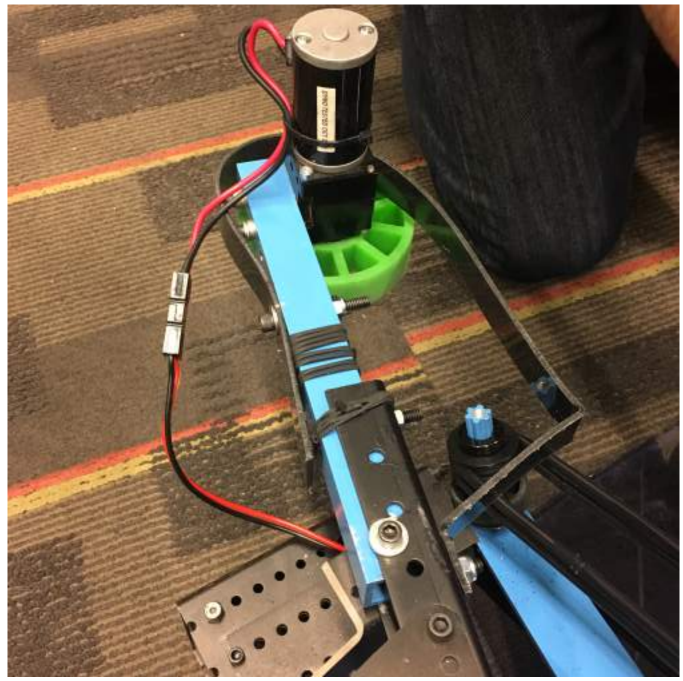

Fig. 3. A view of the intake wheel assembly and guard from behind

Our final intake design used 2 4″ Green AndyMark Compliant Wheels (shore 35), powered directly by BAG motors through a 10:1 VersaPlanetary gearbox that actuate into position using pneumatic cylinders. In their resting position, the wheel centers are approximately 16″ apart, which gives a total of 1″ of compression absorbed by the wheels and their elastic mounting.

The arms have a compound joint which consists of the base actuated component (1″ internal c-channel as found in the old Kit of Parts) with 1″ 6061 square aluminum tubing (1/8″ wall) inside. They are held into place with elastic surgical tubing. There are also polycarbonate guides around the wheels to help with intaking a variety of orientations of the cube. Without these guides, the cubes would often get stuck in a diagonal orientation when being intaken, which is fine when scoring on the EXCHANGE, but not when scoring in the SWITCH or SCALE.

3.2.3 Effectiveness

Our intake was in general pretty effective. It occasionally had issues intaking POWER CUBE into the wrong internal orientation, but this was not associated with any particular orientations of the POWER CUBE relative to the robot. We estimate it took blocks in correctly around 50% of the time, which is unacceptable for an actual competition, but with the relatively few iterations we had, made us pretty

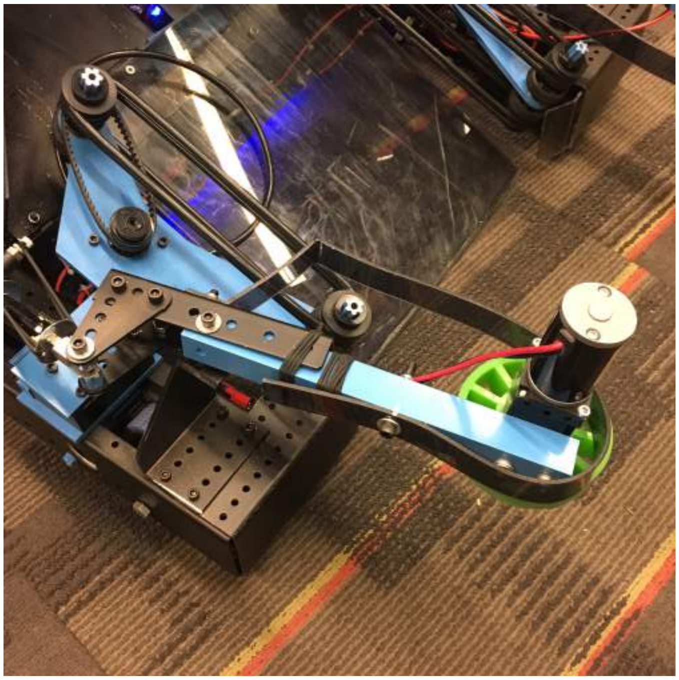

Fig. 4. A loot at the elastic joint– the blue bar pivots around the bolt attaching it to the black part

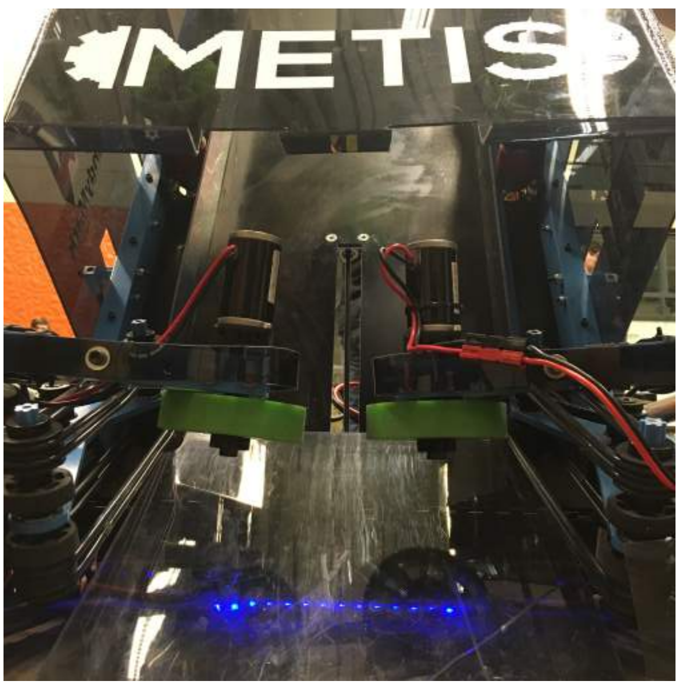

Fig. 5. A view of the intake while closed

confident we were on the right path, especially as it almost never failed to intake the POWER CUBE, just failed intaking it to the correct orientation.

3.2.4 Improvements

The steps we would like to try to improve the intake include adding a second set of wheels after the first set, trying different types of compliant wheels, and trying wheels that aren’t compliant. We would also like to try higher powered motors and different gear ratios on the intake, as we simply

Fig. 6. A view of the actuated intake from the top

chose gear ratios based on what we had ready to install immediately. In general, intakes require a lot of iteration, and for ours to really be awesome we needed some more iteration!

3.3 Transfer

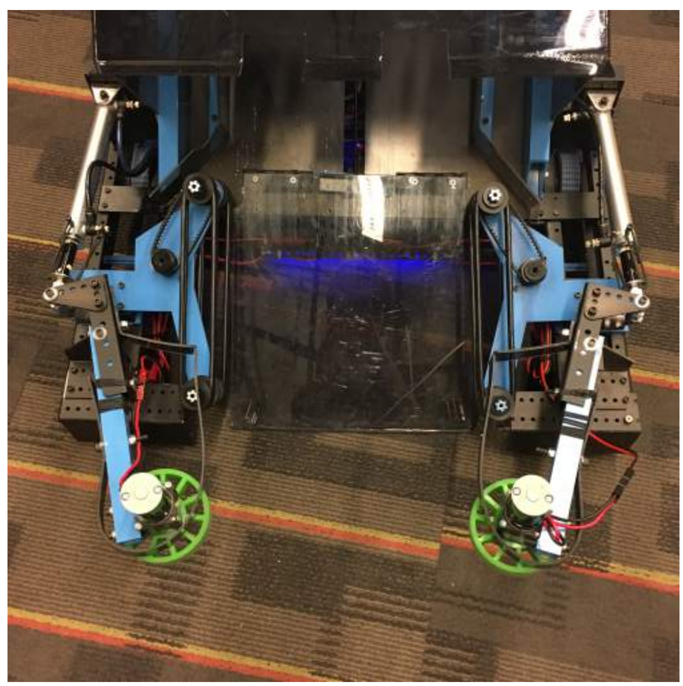

Fig. 7. The full intake-to-transfer-to-shooter path

The transfer was a mechanism we needed to develop to move the POWER CUBE off the ground and into the shooter in a consistent orientation. The transfer to a shooting mechanism is often as important as the shooter itself for having a consistent shot. Consistency is everything for these mechanisms, especially when you only can carry one game object at a time. It needs to load quickly and accurately, every time.

3.3.1 Concept

Our concept was a simple and well-tested mechanism from previous seasons– polycord rollers, potentially with compliant wheels on either end. These would be mounted at an angle to pull the POWER CUBE up a ramp and into the shooter. In order to accommodate blocks that were intaken in a vertical orientation, we also tested a bar to knock the POWER CUBE down, helping us ensure a consistent orientation in the shooter.

3.3.2 Execution

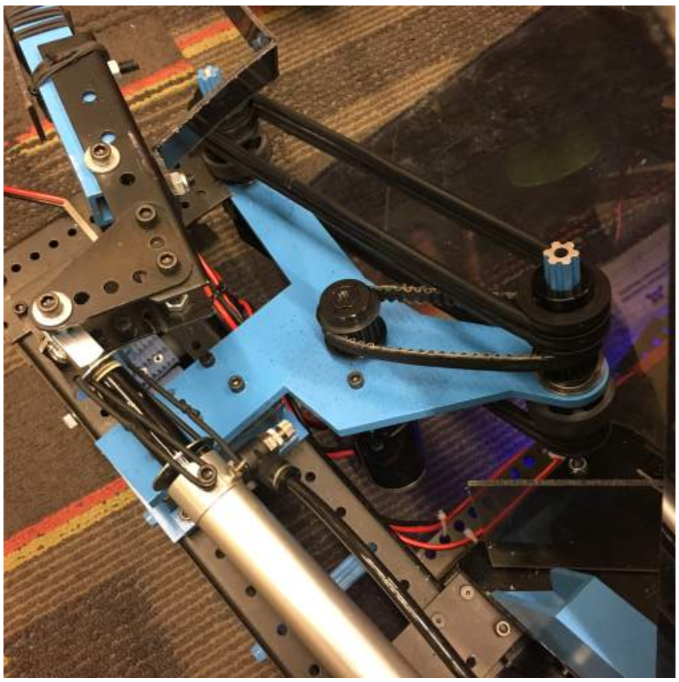

Fig. 8. The left side of the transfer

Our final transfer rollers used 4 bands of black polycord from West Coast Products on each side, with 1.625″ compliant wheels on either end of the rollers. The polycord is approximately 13″ apart from each other, which ended up on the larger side of that tolerance, meaning the polycord only touches the POWER CUBES with they enter at an angle. The transfer is powered by two BAG motors through 10:1 VersaPlanetary gearboxes, with power transfer via an HTD belt to the internal side roller and through the polycord from the internal roller to the external roller. Additionally, the shroud covering the shooter serves to kick the POWER CUBE down if it enters in the vertical orientation. The ramp that the transfer carries the POWER CUBE up is hinged in order to allow it to ride over the bump in the center of the field.

3.3.3 Effectiveness

The transfer was the most unsatisfactory part of our robot. While we almost always were able to load the shooter with it, often it took multiple full actuations of the assembly and some fiddling to get the POWER CUBE properly seated. This is completely infeasible for an actual competition, where quick and consistent transver of the POWER CUBE into the shooter is critical.

3.3.4 Improvements

Overall, the transfer needs to be improved in order to more consistently load the shooter, as well as to ensure we can cross the field bump in both directions of the robot. Our original plan for the latter was to add a small pneumatic cylinder to push the ramp off the ground, which we were unable to do in the limited timeframe of the robot in 3 days build. Fortunately the robot as is can cross the bump in the center of the field as long as it does it backwards. In order to more consistently load the shooter, we would like to try inserting 2″ compliant wheels at the top of the transfer in order to kick the POWER CUBE a bit further in.

3.4 Shooter

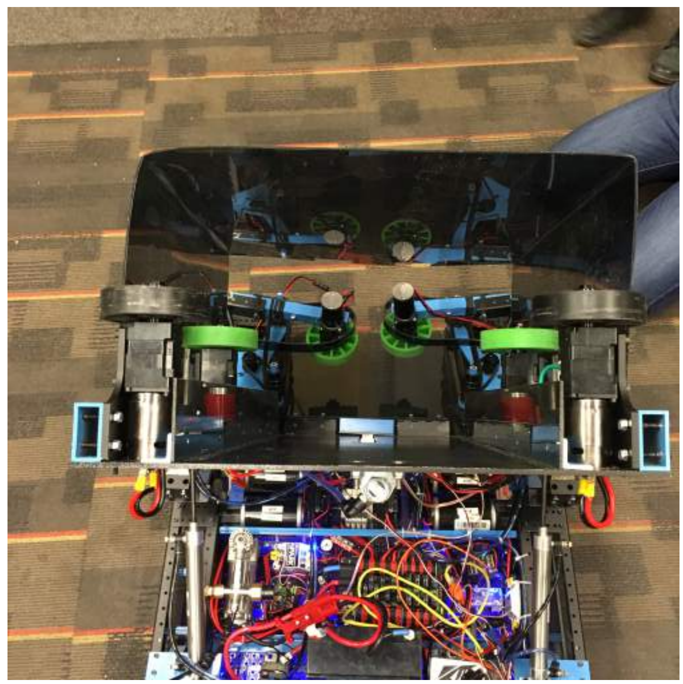

Fig. 9. A view down the shooter's throat

In order to score the POWER CUBE in the SCALE and SWTCH, we elected to use a shooting mechanism to fire the POWER CUBE into the SCALE and SWITCH. For this mechanism to be effective, it needs to have a consistent shot with minimal tumbling of the POWER CUBE as it lands on the SCALE or SWITCH.

3.4.1 Concept

Our original concept for our shooter came from our original intake prototype, which was capable of ejecting POWER CUBES with considerably more force than expected, from there, we prototyped a two-wheel and then a 4-wheel shooter, and found the 4-wheel shooter was capable of ejecting a POWER CUBE well in excess of our target height of 84″, and with minimal tumbling.

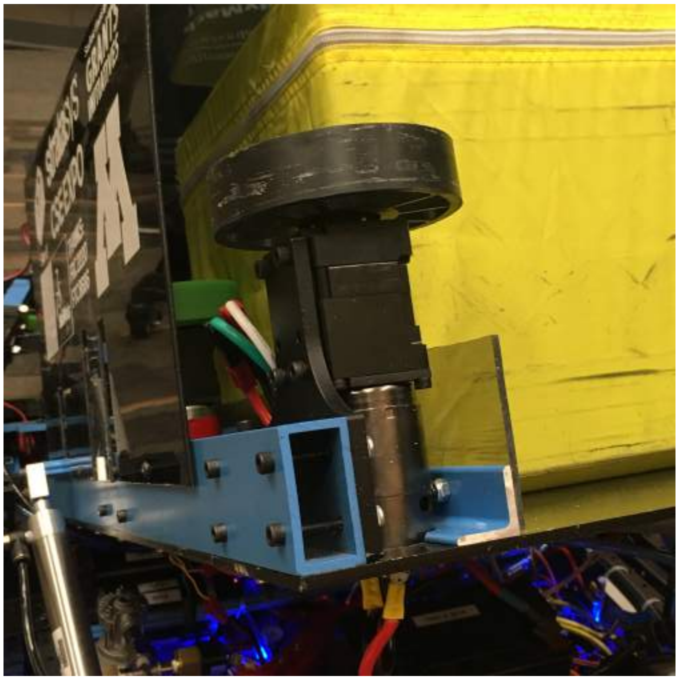

Fig. 10. The VersaPlanetaries were mounted to the shooter using custom waterjetted 1/4" aluminum plates

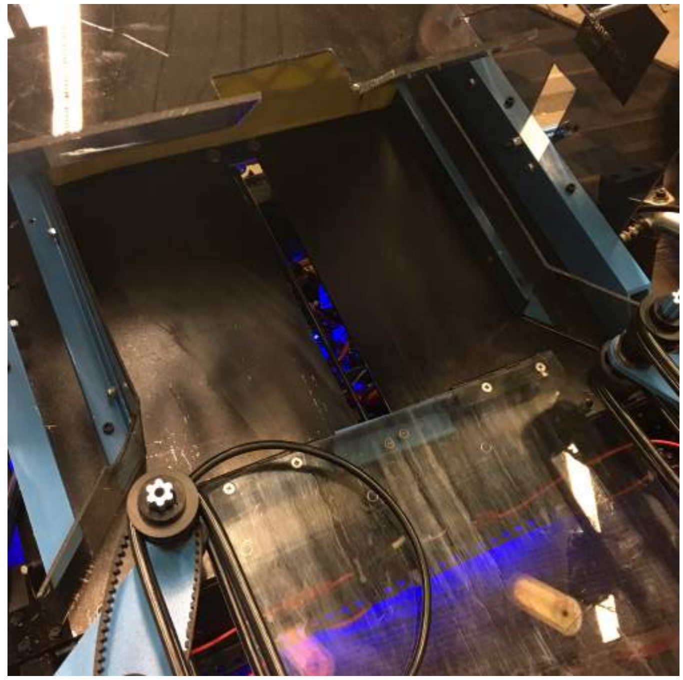

Fig. 11. The pneumatic cylinder that pushes the POWER CUBE into the shooter

3.4.2 Execution

The final shooter consists of two sets of AndyMark compliant wheels spaced just over 13″ apart. The accelerator (first) set of wheels are shore 35A (green) AndyMark Compliant wheels powered off of AndyMark RedLine motors through a 9:1 VersaPlanetary gearbox. The second set are are 12.5″ in front of the first set and are shore 60A (black) compliant wheels powered directly by 775pro motors through a 3:1 VersaPlanetary gearbox. These wheels are mounted approximately 16″ apart, putting about 1.5″ of compression on the POWER CUBE. The POWER CUBE enters the shooter by being pushed in with a pneumatic cylinder with about 12″ of stroke mounted to the bottom of the shooter. The shooter itself is actuated from a 30 degree angle for intaking and scoring in the SWITCH to a 70 degree angle for scoring in the SCALE. This actuation is performed by 2 pneumatic cylinders. The shooter also has a 1/8″ polycarbonate shroud to prevent blocks from falling out while in transit.

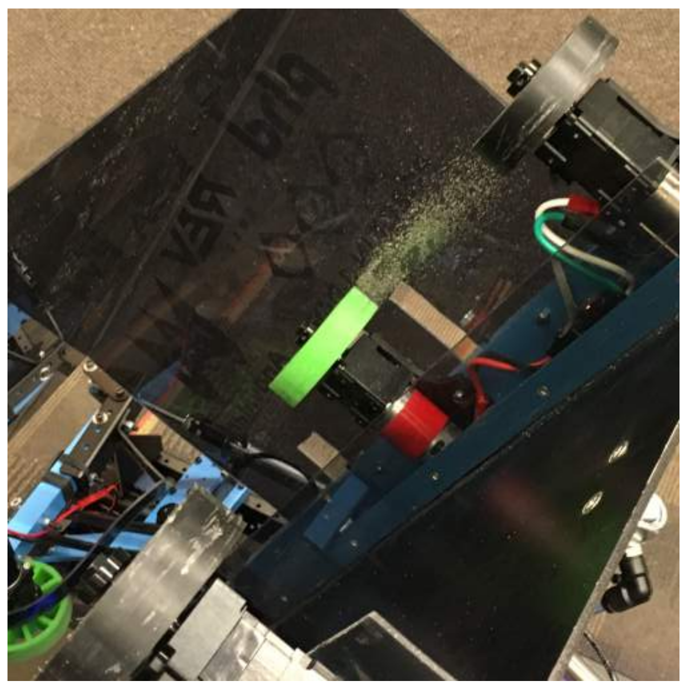

Fig. 12. The accelerator wheels rubbed against the shroud on one side, causing accelerated wear and wheel splatter

3.4.3 Effectiveness

The shooter was the most effective and consistent part of our robot. It was able to softly loft the POWER CUBES into the SCALE and fire them into the SWITCH with equal ease. We had no issues scoring from our desired position against the field perimeter, or sometimes even nearer. Unfortunately we were not able to test with more than one block already in the SCALE, and we would recommend teams do this before committing to a shooter design, as it is the primary question left in our minds about a shooter-style robot. Fortunately, even if this is difficult, Metis as is would be a very effective SWITCH and EXCHANGE robot.

3.4.4 Improvements

Loading is at the top of our minds for improvements to the shooter, as well as trying different types of compliant wheels, including blue (shore 50A) and maroon (shore 45A), for the accelerator stage. We may also want to tweak the gear ratios and further optimize the shooter's size. Additionally, while our exit wheels have encoders on them, the accelerator stage does not, and we would like full PID on all four wheels to enable more precise shooting. We also needed a more tightly toleranced shroud and/or some support for it to avoid the wheels rubbing on the accelerator stage.

4 Extras

4.1 Electronics

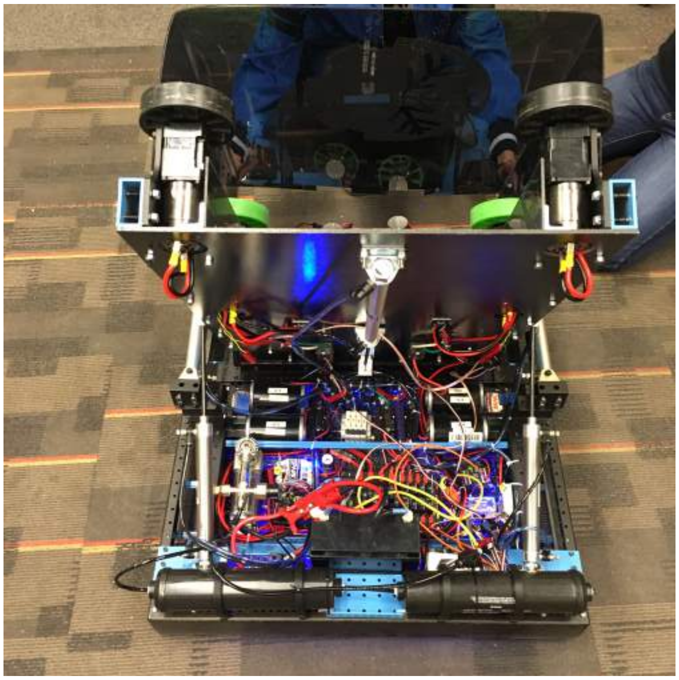

Fig. 13. A view of our electronics

The electronics and pneumatics for Metis are almost entirely contained in the AndyMark frame, and are relatively compact and accessible. Some of the particular features we are happiest with are products donated by our sponsors for us to use, including the REV Blinkin LED module that made setting up LEDs extremely painless compared to the previous years we've done it, and the REV analog pressure sensor, which was fantastic for monitoring air pressure on a robot that uses as many cylinders as ours does. Our electronics are 100% FRC legal, and primarily use Victor SP speed controllers, with two Talon SRX controllers on our exit shooter wheels and two REV Spark motor controllers on the transfer. Thanks to NI, CTRE, and REV for making such awesome products!

4.2 Aesthetics

The coloration on Metis was carefully considered from the beginning by our expert aestheticians. Below is a quick sketch on top of our CAD model determining what parts would be colored what. The coloration on Metis was achieved using an in-house powder coating setup, as described in our 2017 white paper on powder coating. For the final robot, we exclusively use dark tinted polycarbonate, which gives the robot a more professional look than clear polycarbonate. The decals on the shroud are adhesive vinyl cut on our Silhouette Cameo. This year we also used a REV Blinkin LED driver to control our underglow LEDs, which act as our robot signal light– they're on when the robot is, slowly blinking when enabled, and pulsing rainbow while firing. We are extremely happy with the Blinkin driver, and can't recommend it enough to teams looking to easily and painlessly control LEDs. The pneumatic tubing we used on this robot is bonded tubing from Automation Direct. The bonded pneumatic tubing was useful for us as it helped create a cleaner robot as it reduced the total number of tubing runs we had to have on the robot.

Fig. 14. A view of our sponsors panel on the shroud

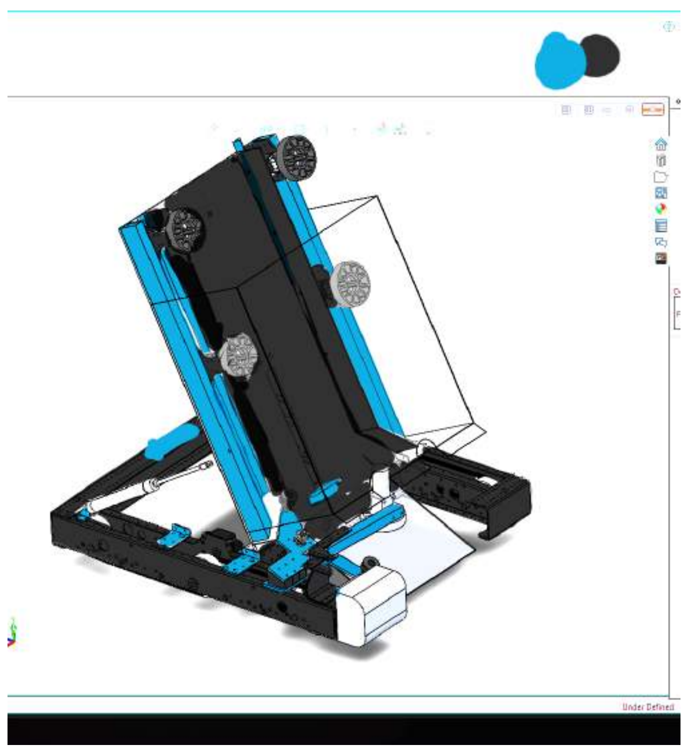

Fig. 15. The paint over of the robot's colors

4.3 Bumpers

This year for the first time we built bumpers for our Robot in 3 Days, and are very happy with how they turned out.

Fig. 16. Our bumpers, before being attached

We used furniture grade plywood and stiff pool noodles from Amazon, covered by RobotPromo’s bumper material, with iron-on vinyl decals also from RoboPromo. If you’re looking to make your bumpers easier this year, we’d highly recommend them!

5 Contacting the Authors

Team ’Snow Problem may be reached in order to ask questions on our Chief Delphi thread, on Twitter (@SnowProblemz), or via our Twitch stream during the three day build. After the build, we will still be answering questions on the thread and via email (at gofirst@umn.edu). We are doing this for you, the FRC community, and are happy to answer questions and discuss our designs with you.