'Snow Problem Robot Strategy for FIRST Steamworks

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Abstract—This white paper provides a quick summary of our strategy, followed by a look at all the components that were affected/considered when deciding the strategy. It also includes design considerations that were brought up while we were discussing strategy and design decisions that were made based on our strategy. This document will be followed by another white paper describing the solution we arrived at for the 2017 Snow Problem robot, including a breakdown of our individual mechanisms.

1 SUMMARY

PRIMARY components of our strategy are:

- quickly load and score gears
- intake and score large amounts of balls quickly in the high goal
- add a climber if we have the space

This leads to numerous design constraints. We wanted a very large intake so we went with the short robot volume constraint. [1] We also wanted to be able to load gears consistently and quickly, therefore a design that would be ready to accept the gear as soon as we were in position was essential.

One of the primary goals of Snow Problem is to help teams we believe you can learn from our successes as well as our failures which is part of why we are trying to do everythingeven if some of our mechanisms dont work, as long as we document the failures they will still provide some benefit to teams.

2 THE DRIVE TRAIN AND FRAME

We start with what we consider to be the primary goals of each of these parts of the robot.

- The goal of the drivetrain is to get our robot where we want to be when we want to be there.
- The goal of our frame is to support all of the mechanisms we want to attach to our robot.

2.1 Gear Ratio and Wheels

Gear ratio and wheel size are two essential components how fast do we need to go? There are several key distances in this game, but the major one were looking at is the sprint between the LOADING STATIONS and the LIFTS on the AIRSHIP. This is approximately 45 feet maximum, with a turn included. This is a similar in length to the cycles teams ran in 2013 for Ultimate Ascent.

While we have a 22.67:1 and 7.56:1 ratio on our Evo shifter, we wanted to run the calculations for the fastest we could reasonably sprint that length. With a 4-CIM drivetrain our current assembly with 4 wheels will do that distance in approximately 4 seconds. Switching to the fastest available ratio for the Evo brings that down to about 3.33 seconds.[2] Obviously in a live match, the cycle would be slightly slower since we need to account for the deceleration at the end, but we can also optimize our shifting to accelerate in our low gear (higher torque) and switch to our high gear when were up to speed. This is called auto-shifting and has been used with some success by various teams, including FRC Team 33 - The Killer Bees.

Were we ordering our own gearboxes, we would likely order ones that had the faster sprint distance (4.77:1). As it is however, we believe that the performance difference is minor enough that its unlikely most teams would really notice it unless they are playing at a very high level.

2.2 Frame Size and Robot Dimensions

An interesting part of this years game is that there are exactly two potential robot volumes. We spent a decent amount of time considering the low (24 maximum height frame) versus the high (36 frame). Ultimately based on our strategy, we decided on the low height frame because it would enable us to have a wider intake as well as keep almost all of our electronics and battery low to the ground, leaving a clean space for mechanisms above. With 4 wheels the maximum height for our drive train and lower frame is approximately 5 off the ground. This leaves us with an almost entirely open area above the drive train.

One of the key reasons this allows us to have a wide intake is that it enables us to do an over or through the bumper intake while still maintaining a reasonable area for electronics on primarily one level. We felt this would be impossible for us to do in a way we were comfortable with in the smaller frame perimeter.

We are sacrificing approximately 9 of the length of our robot in order to have an over the bumper (OTB) intake. This is, in retrospect, more than we needed to sacrifice due to a variety of factors. Mostly, we were trying to play it safe and give ourselves plenty of space to drop down our intake.

1. Volume A, 36″ x 40″ x 24″, as defined by ¡R03¿ in the 2017 FRC Game Manual

2. These times are calculated using Ether's Drivetrain Acceleration Model

3 Gears and Rotors

During our strategy session, we identified scoring GEARS as the most important task to us in the game for success in at least the qualification rounds. There are a minimum of 160 points (4 rotors at the end of TELEOP) and a maximum of 280 points (2 rotors at the end of AUTO, 4 rotors at the end of TELEOP) available through GEAR manipulation during qualification rounds.[3] In eliminations, this is increased to 260 and 380 respectively. If it is clarified that ROTORS spinning in AUTO do not count for another 40 points (each) in TELEOP, we are still looking at a maximum of 200 points from ROTORS/GEARS. That is major points, especially with a maximum of 150 from climbing for an alliance and the relative difficulty of scoring many FUEL pieces in the High GOAL of the BOILER, or the inefficiency of scoring in the low GOAL. Additionally, scoring at least the first three ROTORS without assistance from alliance partners appears to be doable for one robot.

3.1 Travel Time and Cycling

One of the key considerations for scoring gears is how fast it is possible to move from the LOADING STATION to the LIFT. We analyzed how fast our Evo shifters are capable of making this distance with 4 wheels in the drive train section of this paper. This was approximately 4 seconds each way. In order to score 6 GEARS, and do nothing else for the entire match, we are looking at approximately 22.5 second cycles (this presumes the single gear that is already on the AIRSHIP is used). With at least 8 seconds of that used by driving between the LOADING STATION and the LIFT, we are left with approximately 14.5 seconds for aligning with the LOADING STATION and the LIFT. This is aggressive, but we believe it is doable with practice. Going higher than this will be difficult, but we anticipate high caliber teams to be capable of doing it. In 2013, FRC Team 1114 (Simbotics) pushed the limits of how fast it was possible to cycle a similar distance under arguably harder conditions (loading and shooting multiple game pieces).

Exclusively scoring GEARS is perhaps not the best option and it may not be true that nobody on our alliance is helping with GEARS. There are a number of other situations which are important to consider if we score 1 in AUTO (which we would hope to do if we were attending an actual competition), we would reduce our load to 27 seconds per cycle, which we consider very doable with sufficient practice. Add in other alliance partners capable of scoring gears in AUTO and our cycle time may reduce to a level which makes all 4 ROTORS a feasible proposition if at least 2 robots are capable of scoring GEARS (in order to get all 4 ROTORS running, 12 GEARS are required, half of which are required for the last ROTOR). If 3 GEARS are scored in AUTO and 2 robots are capable of scoring in TELEOP, we are looking at a 5-GEAR game for one robot and a 4-GEAR game for the other. These are both doable cycles for practiced drive teams, potentially leaving time at the end for other activities.

One of the key conclusions we arrived at regarding cycling GEARS was that it is highly dependent on what our alliance looks like. 3 high quality GEAR cyclers with good GEAR autonomous modes could potentially get all their ROTORS spinning with more than a minute left in the match. Based on this, were making an educated guess that one of the things, especially at early regionals, that highly seeded teams will be looking for in alliance partners is teams that can consistently deliver 3-4 GEARS during TELEOP, regardless of whether it will take them the entire match to do so or not. The extra 100 points from getting all the ROTORS in eliminations is simply too large a prize to leave on the table.

3. Based on Table 4-1 in the 2017 FRC Game Manual (p. 42)

3.2 Loading

We identified in our strategy session the need for two distinct parts of our GEAR scoring mechanism one of those parts is the loading mechanism. We use mechanism loosely here, as we are working (prototyping) off the assumption that we can use a mostly static mechanism to accomplish consistent and fast loading. Two components of making loading fast are making it **easy to line up (making it the full robot width, or close to it)** and making sure **the GEAR is quickly in a position where we are comfortable moving at high speeds with it.** Thus, those will be our two goals when designing our loader.

3.3 Scoring

The key goals for scoring are similar to loading we need to align fast and we need to be able to start our next cycle fast. Our ideal motion for scoring GEARS is to move forward into the peg and then move backwards, allowing the barb to catch on the gear quickly. This has the advantage of not requiring the robot to wait for a PILOT to remove the GEAR, but adds some complexity. A second avenue for prototyping would involve something entirely static or something that only actuates forward. The key thing for us though, when considering the tradeoffs for completing a GEAR mechanism, was that we believe it can be done with no motors involved and potentially with no actuators of any kind (though we may end up using pneumatic cylinders). This enables us to save space and current for our other active mechanisms.

3.4 Scoring in AUTO

While we are a Robot in 3 Days team without access to the vision targets or the space necessary to test an autonomous mode, we see scoring a GEAR in AUTO as extremely important. As such, though we may not be able to test this functionality, we will at least be including it within the programming of our robot. Additionally, since the PILOTS need to get the ROTORS moving (and registered by the FMS) by the end of AUTO, doing this quickly and immediately is vital. Our plan for AUTO, were we competing, would be to first score a GEAR, then move to score FUEL.

4 Fuel and Boilers

FUEL and scoring in the BOILERS was identified as another key component of our robot strategy. While we believe this to be somewhat undervalued in the game rules, one of the key components of Snow Problem and most FRC teams is that our robot will be used later for demonstrations, and a robot that shoots balls in the air makes for a great demonstration robot. We also believe that tight matches may very well be largely decided by BOILER points and that the extra ranking point available is not to be underestimated, especially at highly competitive regionals or championship events.

4.1 Hoppers

One of the components discussed in our strategy session was how viable loading exclusively from the HOPPERS or LOADING STATIONS would be. We arrived at the conclusion that this would be extremely easy to defend againstall the other alliance needs to do is hit all the HOPPERS in AUTO or at the beginning of TELEOP. From this conclusion, we decided to design an intake capable of retrieving FUEL from the ground.

The exception to this conclusion is scoring from the HOPPERS in AUTO. Each side of the HOPPER contains 50 FUEL pieces and robots are allowed to preload 10 pieces. If a robot is able to activate a HOPPER, capture the majority of the FUEL from one side, and score it, even at a 50% accuracy, you seriously reduce the load on your alliance to score in the BOILER and get that extra ranking point. This will be difficult, but we anticipate multiple high level teams guaranteeing themselves that ranking point in AUTO. The time breakdown of this is extremely aggressive, involving moving from starting position to the HOPPER and then to scoring position.

4.2 Storage

How much storage is necessary is highly dependent on overall strategy, how fast we can intake and subsequently score FUEL, as well as how long we plan to go between scoring periods. Our current plan is to try to intake FUEL while we are cycling GEARS, and then move to scoring FUEL. To this end, we estimated that storage of approximately 50 to 100 FUEL pieces would be adequate for our purposes. This is between 1/12 and 1/6 of the total FUEL available on the field, and an amount that we felt was reasonable to actually score if were only doing one run at the BOILER, while also reasonable to refill if we did multiple runs.

4.3 Intakes

A large driving factor of our robot design is the intake. For ease of use for the drive and for the strategic goal of holding lots of FUEL, a large intake is essential. This allows us to intake large quantities of FUEL quickly. Exact specifications were not decided on during our strategy session. The main decision made about our intake were that it would be over/through the bumper, since we wanted to reserve the base part of the robot for our electronics.

5 Climbing

Climbing is a very interesting challenge for this years game. For our strategy however, it is not the main focus. We are planning to build a concept climber, though we are very conscious it may not work.

5.1 Loops

Based on the current rules, it appears that it is legal to have a loop of up to 10 in length on a rope brought by a team. We feel engaging a loop to start the climbing process is significantly easier than designing a mechanism to grasp unlooped rope. Once the loop is engaged (most likely with some sort of peg), a climber that winches the rope This makes climbing significantly easier, as a loop is easy to wind up around pegs or a drum.

5.2 An intake climber?

The concept we had for a climber was interesting enough that we decided to devote the resources to building it. Essentially, we are combining the intake and climber mechanisms. The upside to this is that we are essentially just overbuilding our intake mechanism, and if our climber concept fails, we are left with a really intense intake, which isnt a bad thing.

6 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.