2017

Drivetrain Technical Report

Frog Force 503 Drivetrain

2/10/2017

Contents

Deciding the Drivetrain Architecture

Down below is the graph where we rated how important a certain part of the drive train was to this year's game. The size of the playing field and general actions that the robots had to do impacted how we rated the stats. Speed and agility in this big of a playing field seemed to be the key of getting the most amount of points, as the table states, those were rated very highly, while things such as traversing the fuel were not very important.

TABLE 1: DRIVETRAIN PUGH MATRIX

	Weight	Swerve	Tank	Holonomic	Slide	Mecanum
Speed	9.3	4	5	2	3	3
Scrub	6.6	5	2	5	5	4
Traverse	6.5	3	5	1	1	2
Agility	8	5	3	5	4	3
Design	5	1	5	3	4	5
Strength	7	5	5	1	1	2
Total		169.7	176.2	120.1	126.4	130.3

- The Pugh Matrix technique was used to decide the type of drive base that would most benefit us during this year's game
- Weighting for the categories was decided by averaging the entire group's preferences out of ten based on being able to travel across the field while having a high amount of maneuverability
    - The group decided that speed was the most important feature this year while the design was not our main focus
- The potential drive base options to choose between were swerve drive, tank drive, holonomic drive, slide drive, mecanum drive
- The rating numbers are based on a scale of 1 to 5 and the average was taken and then rounded from the group data to determine the rating given to that specific drive option in the specified category
- After the ratings were added up tank drive was chosen to be our pick for the year; the tank drive was chosen in place of the swerve drive due to it being a more reliable design due to past years of experience
- Scores were modified due to past experiences of how much the certain spot of the robot impacted us, such as speed and design. Speed is always important while due to the past, design did not play a big of a role

Gearbox and Ratios

We wanted to use a vex gear box because in the past we have used them and as a team we felt comfortable using them. We also decided to use the vex gear box because it fit the needs of this game.

Deciding on a Gearbox and Gearbox Requirements

- In accordance to our earlier decision with the Pugh Matrix and Steamworks gameplay requirements, the group decided that a dual speed gearbox would be beneficial as it would help defend against enemy pushing as well as being quick on the field during cycle runs for fuel and gears
- The group used a spreadsheet calculator to determine acceleration, current draw, speed, slippage, voltage versus time (http://www.chiefdelphi.com/media/papers/3038, Hill Drivetrain Simulator)
    - This calculator was used for a multitude of different gearboxes and gear ratio combinations.
    - A key assumption that we used in our calculator was that we predicted that the drivetrain by itself would be around 10 lbs.
- Looked for smaller gearboxes for packaging
- No sprocket reduction

High Gear Specifications

- Goal Speed - 15 ft/s in 2014, this high gear speed worked well enough for us that we planned to do it again this year
- Current Draw goal - below 30 amps
- Final Ratio – 6.73:1

Low Gear Specifications

    - Goal Speed – 6-7 ft/s
    - Current Draw goal - below 30 amps
    - Final Ratio – 13.85:1

CHART 1: LOW GEAR PERFORMANCE

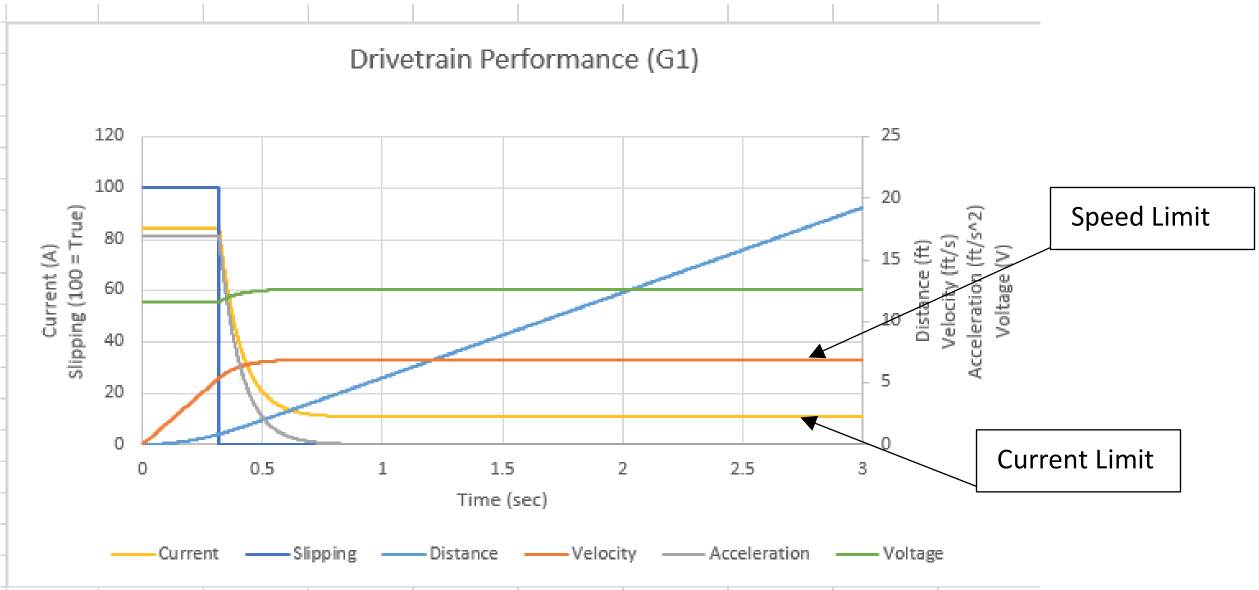


CHART 2: HIGH GEAR PERFORMANCE

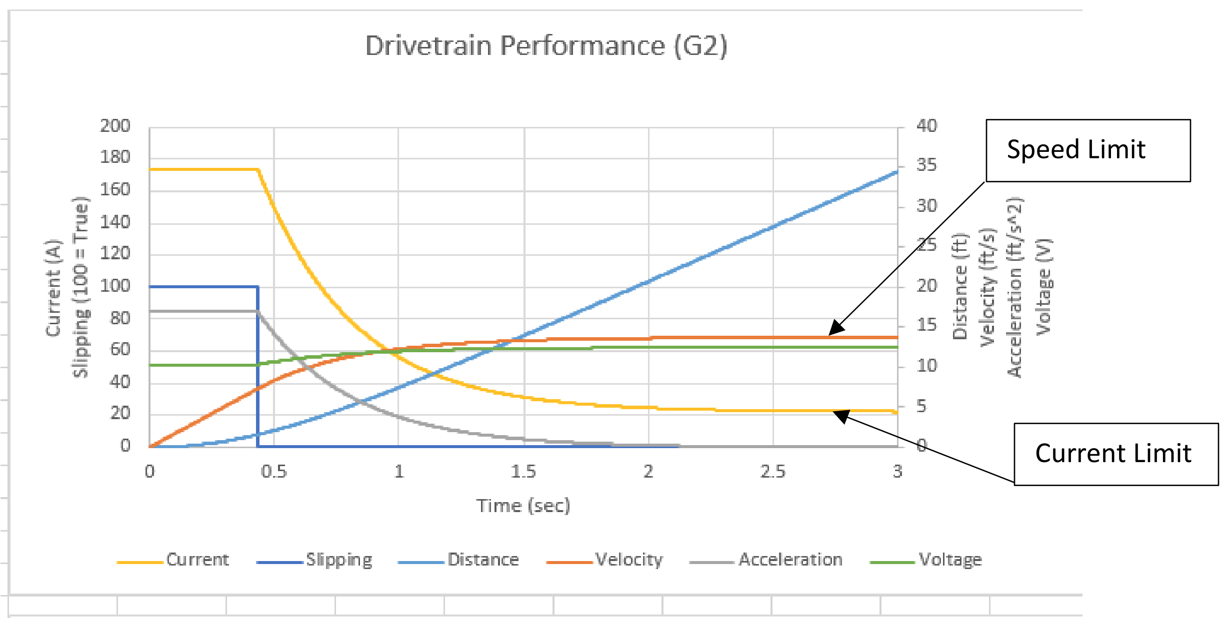
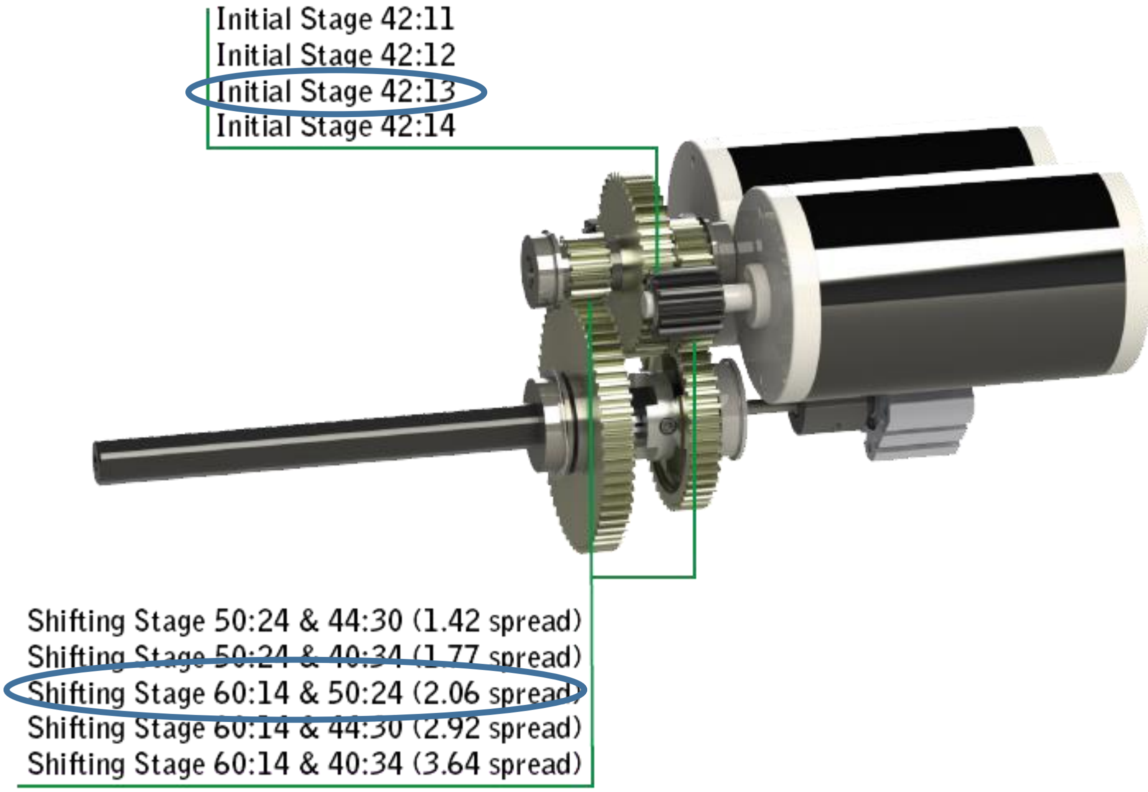


CHART 3: DRIVETRAIN INPUTS

	A	B	C	D
1	Kro	10	lbf	
2	Krv	0	lbf/(ft/s)	
3	Kf	0.82		Drivetrain Efficiency
4				
5	d	4	in	Wheel Diameter
6				
7	M	130	lb	Robot Mass
8	uS	0.804	1.2	Static Coefficient of Friction
9	uK	0.603	0.9	Kinetic Coefficient of Friction
10				
11	Rcom	0.013	Ohm	Circuit Resistance from batt to PDB (inc. Batt Rint)
12	Rone	0.002	Ohm	Circuit Resistance from PDB to motor
13	Vbat	12.8	V	Fully charged Battery Voltage
14				
15	Vspec	12	V	Motor Specification Voltage
16	Tspec	4.841	N-m	Combined Motor Stall Torque
17	Wspec	5310	RPM	Combined Free Speed RPM
18	Ispec	262.5	Amp	Combined Motor Stall Current
19				
20			Efficiency %	Gear Ratio
21	Motor 1:		100%	1
22	Motor 2:		100%	1
23	Motor 3:		100%	1
24				
25	dt	0.001	sec	Time Step
26				
27	G1	13.85		Gear Ratio (Can also mod A20 in Unit Conversions)
28	G2	6.73		Gear Ratio (Can also mod A21 in Unit Conversions)
29	Vmax1	6.92	ft/s	
30	Vmax2	13.74	ft/s	
31	Spread	2.06		
32				
33	LSR	3812		Low Speed RPM to Shift
34	HSR	1852		High Speed RPM to Shift
35	VmaxShift	13.74	ft/s	
36				

FIGURE 1: VEX GEARBOX



Tires and Wheels

Tire and Wheel Requirements and Goals

- High coefficient of friction and traction to maintain position during shooting
- High precision during pivoting of the robot
- Balanced center of gravity
- High Durability wheels
- Balanced and stable robot
- Low scrub

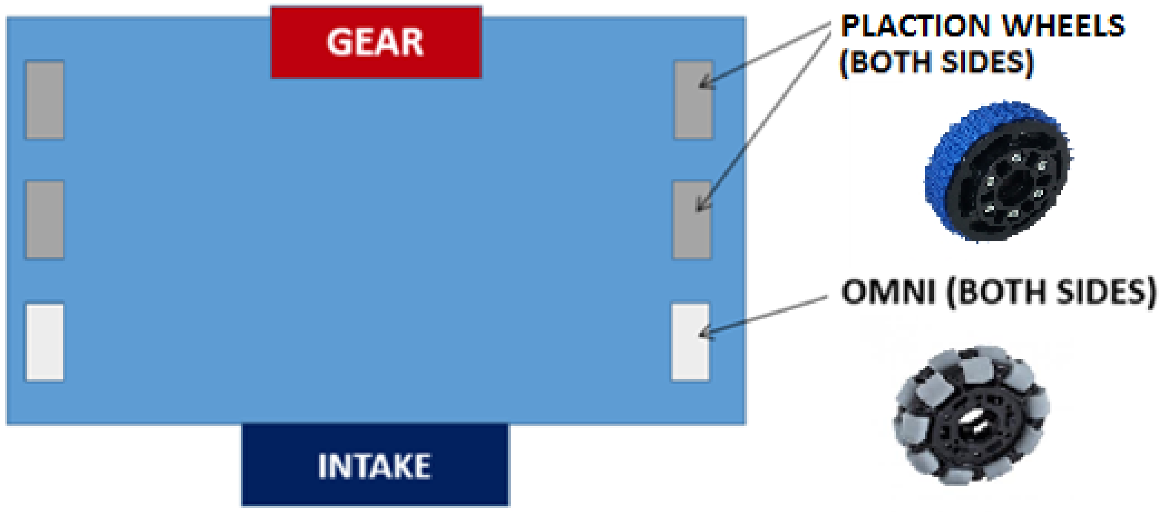
Possible Solutions to Requirements

- A mix of traction wheels to assist in grip and pivot point
- 3 Wheels on both sides of the robot to provide stability and ease of maneuvering
- Centrally located gearbox to balance the robot's center of gravity

Final Drivetrain Solution

- 4" Wheel Diameters
  - Allow the chassis and rest of the robot to stay in frame perimeter
  - Not extremely low to the ground to provide enough clearance for any small obstructions that could appear on the field during gameplay
- 3 Wheels on either side of the robot for a total of six wheels
  - Very stable and maneuverable robot
  - Configuration that had worked fairly well in previous years
- 4 Plaction Wheels located towards the rear end of the chassis; all driven
  - Switched from earlier traction wheels due to significant amounts of wear on the tires
  - Beneficial for reduced scrub
  - Beneficial for bring the pivot point towards the rear for maneuverability
  - Nitrile treads provided the much-needed traction with a higher coefficient of friction than the traction wheels with lower amounts of wear
  - Higher durability than those of the traction wheels, it would be unlikely that there would be enough side load on the robot to fracture the wheels
  - Useful for positioning and remaining in position during shooting in the game
- 2 Omnidirectional wheels (Omni-wheels) located towards the front of the robot; not driven
  - The Omni-wheels would assist in shifting the pivot point of the robot backwards without impairing turning
  - Beneficial for also compensating for the gearbox and the intake system
  - Allow for precise tuning when positioning the robot by not providing excessive friction but still allowing for a stable robot
- Gearbox to be located in the center position of the robot
  - Balance out the robot's center of gravity and help avoid a heavy front or rear that would cause drifting during operation
  - Very little loss of power transmission to the wheels with a West Coast Drive and sprocket system

FIGURE 2: OMNI AND PERFORMANCE WHEELS



Encoders

- Decided to mount encoders directly onto driven shaft for more accurate reading
- Solution was to design and construct a custom mounting system to replicate the D/C mounting surface and output shaft that was originally intended for the encoder. We wanted to replicate the D/C mounting that so the axle wouldn't slip on the encoders.
- After testing our initial concept, we realized that there was still slip on the axles which would greatly impair the reading the encoders were getting from the shaft
- In order to temporarily solve this issue, we stuck aluminum foil tape around the encoder part of our mounting shaft, this increased the diameter and thus, of the shaft therefore increasing the accuracy of the reading we were receiving.
    - The reason we chose to temporarily solve this problem is due to the fact that we believe that the shaft diameter is smaller than anticipated due to the lack of accuracy and precision during machining

Components used in Encoder Assembly

- ¼-20 Male-Female Hex Standoffs
- Custom Encoder Mounting Plate
- Custom Mounting Shaft
- ¼-20 Castle Nut

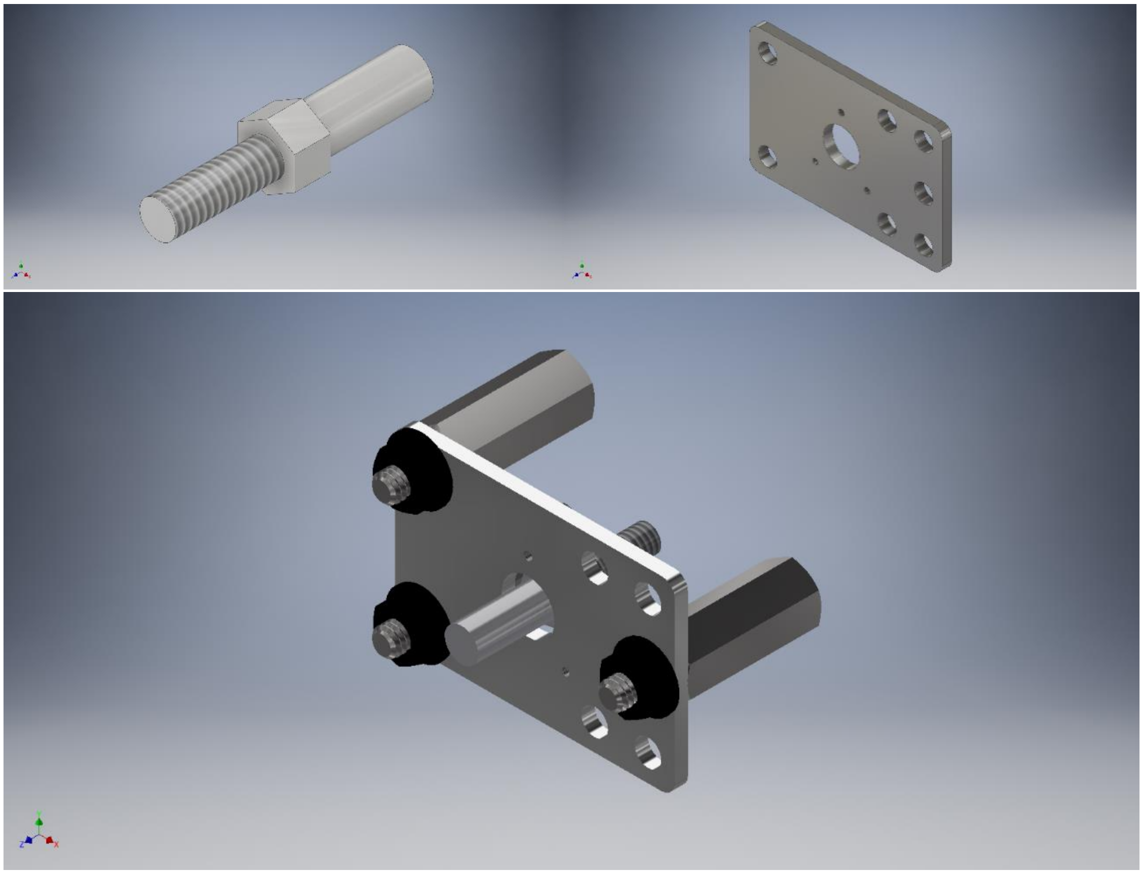
Encoder Mounting Plate Specifications

- 2.625" x 1.75"
- 3 ¼" diameter mounting holes for the hex standoffs
- 4 ¼" diameter holes for easy electrical wiring
- 3 M2.5x4.5 threaded holes for encoder attachment to Plate
- One central .496 diameter hole to allow encoder to attach to custom shaft with tolerance

Mounting Shaft Specifications

- Machined from .25" Hex Stock to allow socket wrench for tightening
- ¼-20 Threaded .75" length attachment to screw into machined shaft
- 8mm diameter end to allow attachment to encoder input

FIGURE 3: ENCODER ASSEMBLY AND ITS PARTS



Chain Tensioning Mechanism

- Due to the varying amounts of tension in the chain for both sets of axles, it was advisable to have a chain tensioning system to ensure that the chain would remain taut on the sprockets

Chain Tensioning Brainstorming Ideas

- A curved Lexan plate riveted onto our 'belly-pan' that would passively push up against the chain and provide a surface for the chain to ride smoothly on
    - Pro: Simple, cheap, in stock material
    - Con: Possible wear on the Lexan plate and having to replace the multiple times, possible over and under tensioning of the chain
- A premade OTS chain tensioner from an online retailer
    - Pro: No-head-ache solution, easy to mount to existing frame
    - Con: Expensive
- An active tensioning system that would utilize a spring and a bolt to actively push up against the chain.
    - Pro: Safest, and most elegant solution
    - Con: very complicated and not feasible due to mounting space restrictions

Final Chain Tensioning Solution

After weighing the advantages and disadvantages of all three systems our final decision was to use the simple Lexan plate as a tensioning system. More in depth look at the function of our tensioning system:

- Manufacture a Lexan plate with a hole on one end and a slot on the other
    - 9.00" x 1.25"
    - .25" unthreaded hole to have a solid rivet point
    - R .125" Slot 1" long to adjust the height of the plate during assembly of the final system
- By riveting two points on the plate closer together than the distance that they are spaced apart we can cause a bulge in the Lexan Plate
- Using this bulge, we can position the plate so that the chain runs over the top of the bulge, effectively creating a simple tensioning system
- OTS Components Required for Mounting the Lexan Plate:
    - ¼"-20 Bolt x 2
    - ¼"-20 Nut x 2
    - ¼" ID ¾" OD Washer

FIGURE 4: CHAIN TENSIONER PLATE AND PARTIAL ASSEMBLY