Team 517
Sample On-Boarding and Orientation

February 6, 2020

Justin Bomwell, Victor Prado, Kalin Burnside

Ryan Dingman, Joshua Jones, Matthew Schrold

Senior Design Team 517

Justin Bomwell
Software Engineer

Victor Prado
Design Engineer

Kalin Burnside
Power Systems Engineer

Ryan Dingman
Controls Engineer

Joshua Jones
Robotics Engineer

Matthew Schrold
Test Engineer

Special Thanks

Angela Jackman

Sponsor

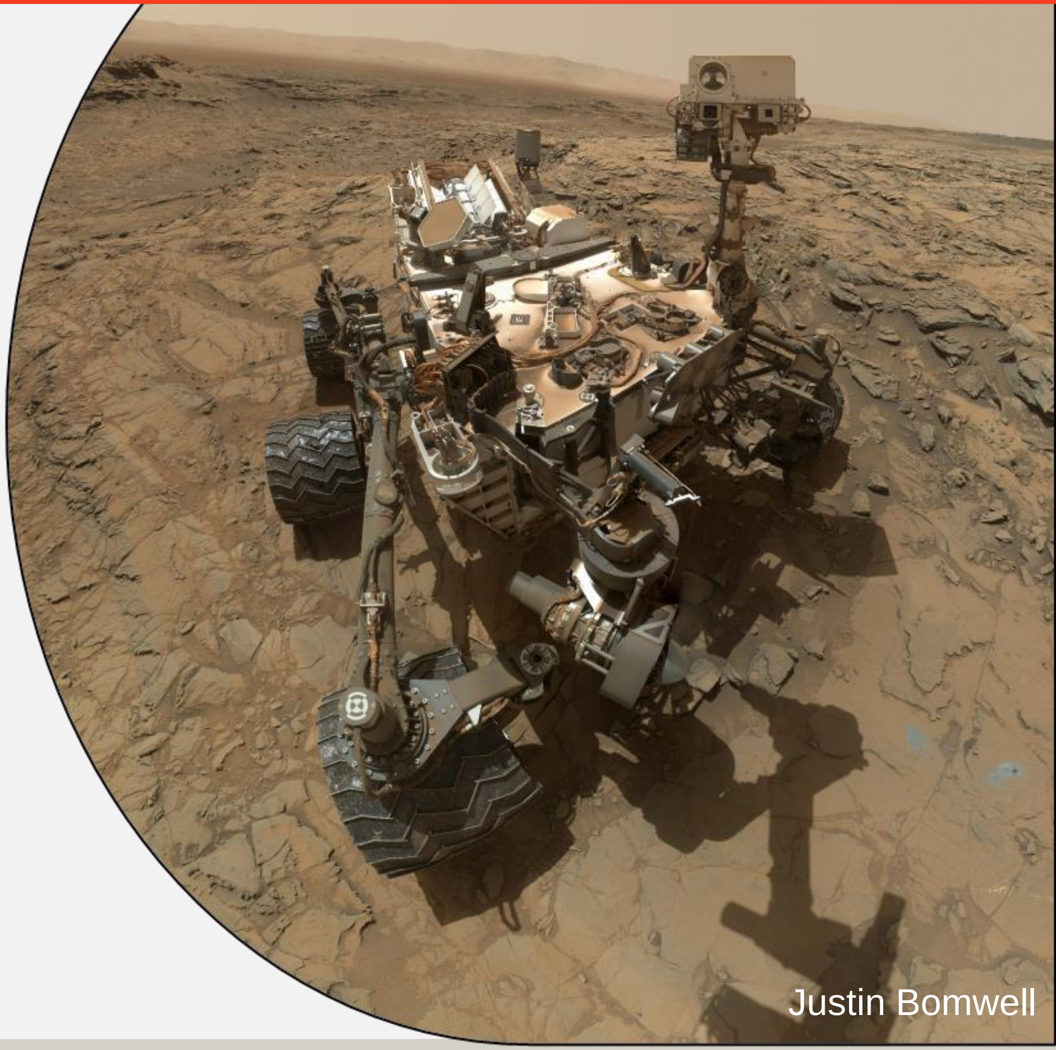
Dr. Camilo Ordóñez

Advisor

Justin Bomwell

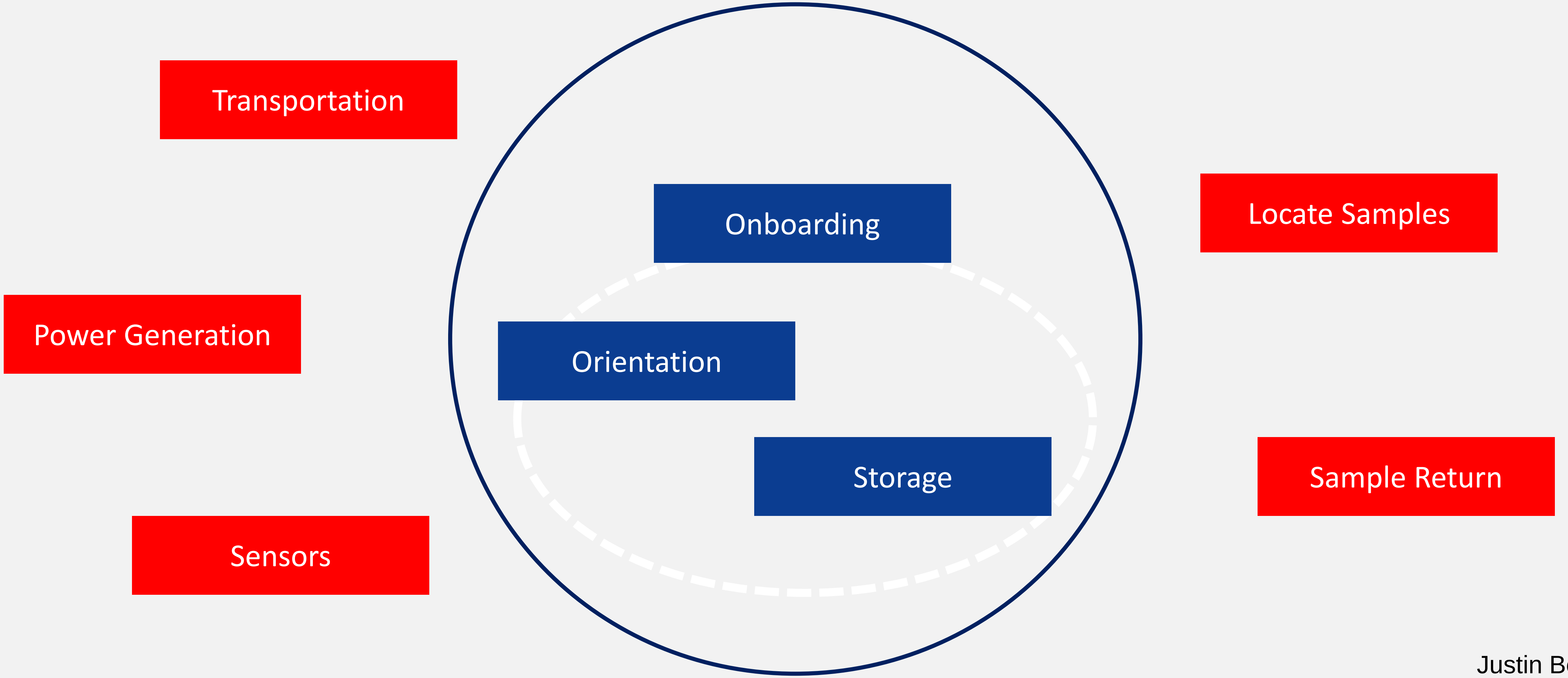
Objective

The objective of this project is for our device to onboard a sample from the environment, manipulate it so that all necessary tests on the sample can be performed, then store acceptable samples



Justin Bomwell

Scope



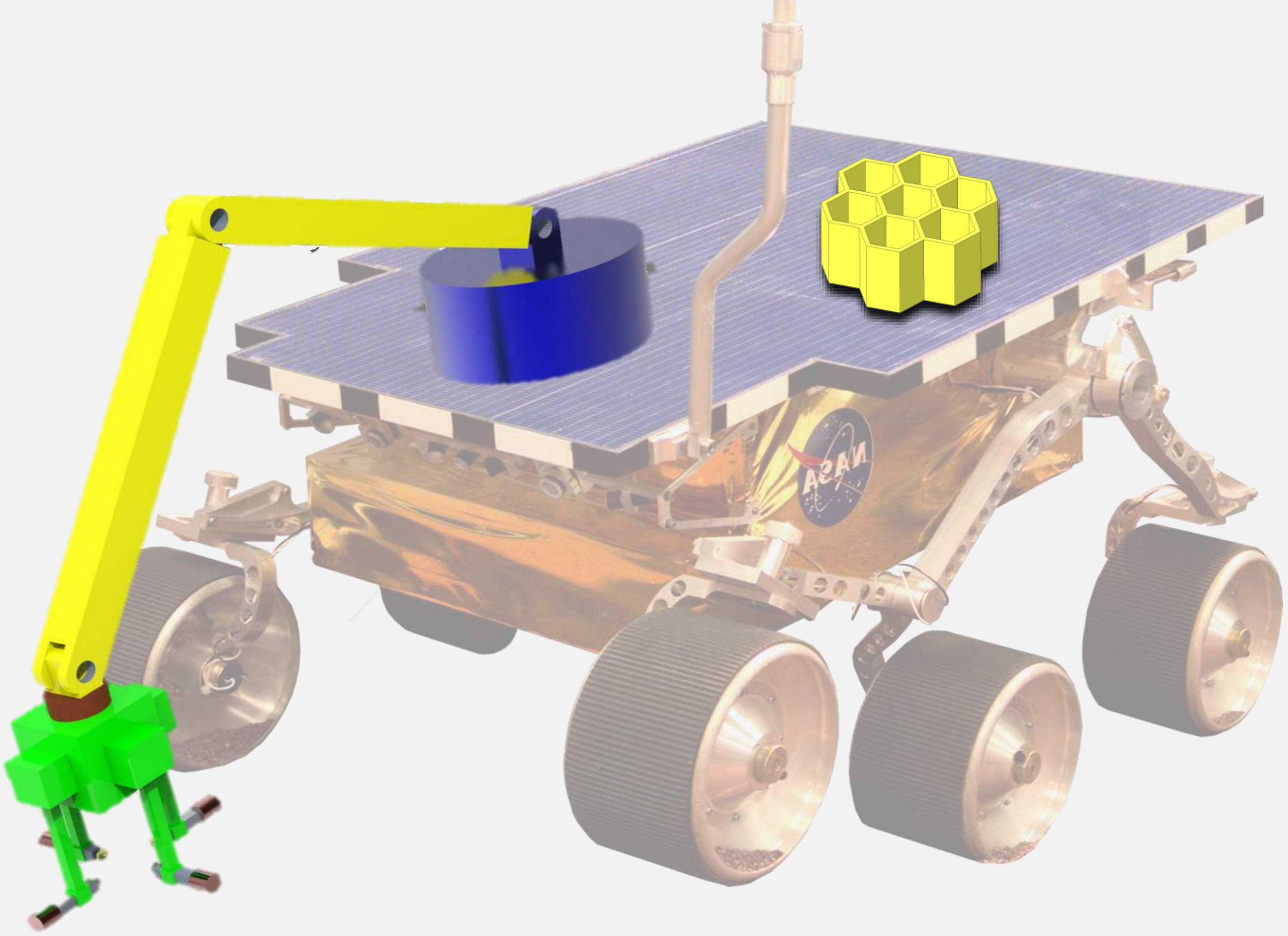
Justin Bomwell

Project Context

What are we making?

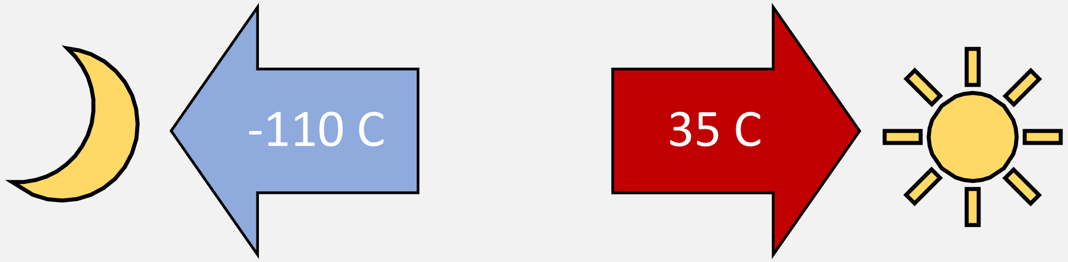
Our full scope includes bringing the sample onboard the rover, orienting it to show the surface to scientific sensors, and then storing the sample on the rover

We're designing all 3 parts but are only building the orientation component due to time and budget constraints



Justin Bomwell

Research – Thermal Range

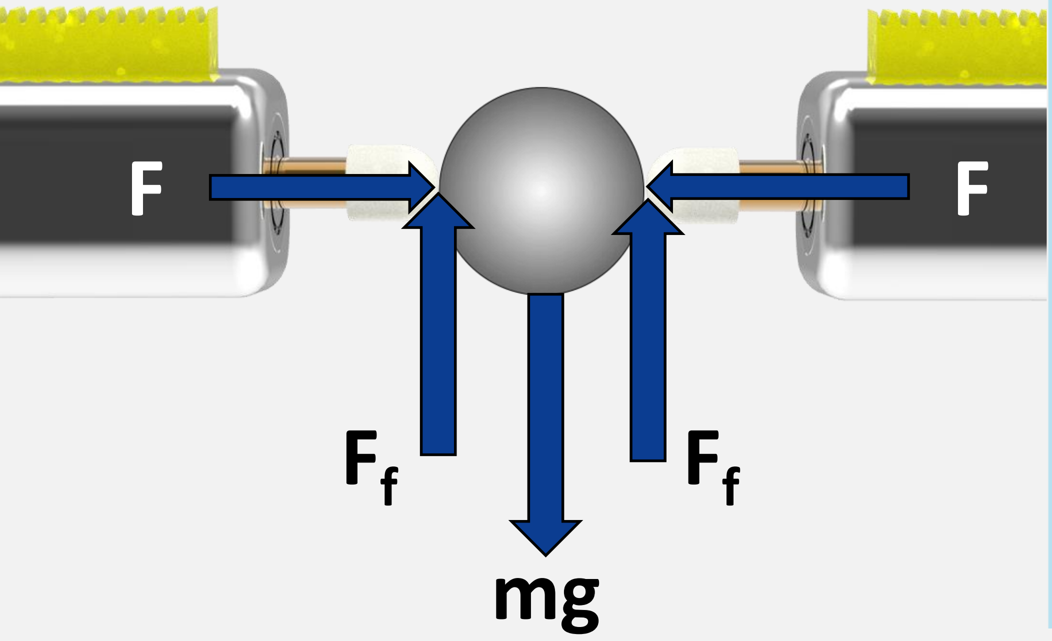


Concerns of ductile/brittle transition for BCC steels.

Material	Yield Strength [MPa]	Coefficent of Thermal Expansion [1/K]*10^{-6}	Density [kg/m^3]
Steel	350+	10.8 - 12.5	7850
Stainless Steel	215	9.9 - 17.3	7480 - 8000
Aluminum	310	21 - 24	2712
Aluminum 2024	324	24.7	2780
Aluminum 6061	276	25.2	2720
Magnesium AZ31B	260	26	1770

Victor Prado

Research – Torque Calculations



With two minimum points of contact from the end effector, the force required to hold the sample without losing grip:

$$F \geq \frac{mg}{2\mu_s}$$

Output torque requirements are determined from the minimum force needed to hold the sample:

$$T_o \geq F r_p FoS$$

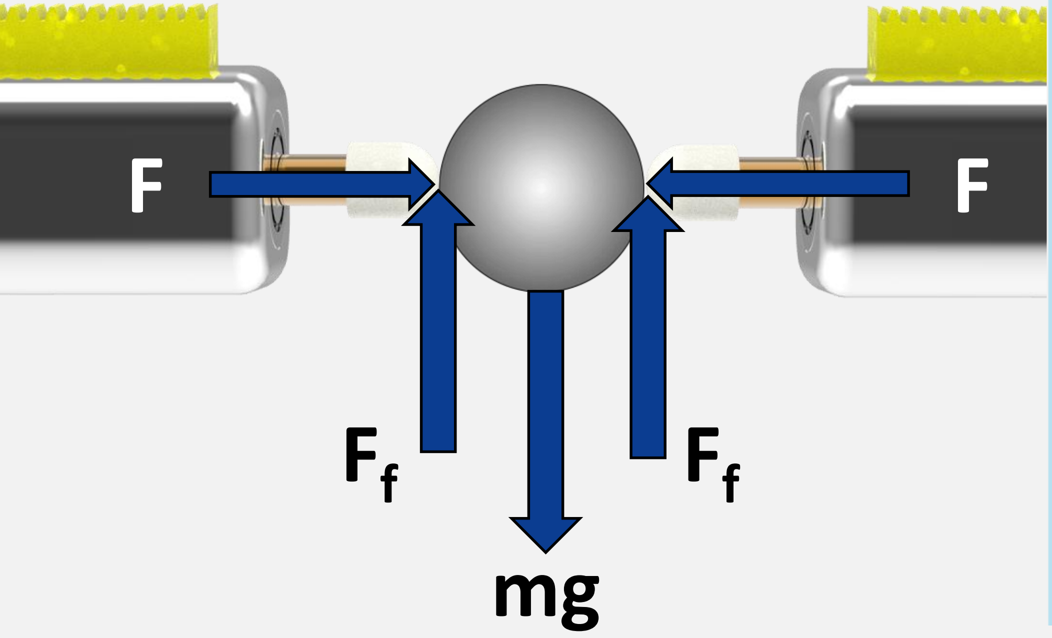
Required contact force and output torque were computed using coefficients of static friction comparable to the fingertips and rock sample, maximum sample mass, gravity, and a factor of safety:

$$F \geq 18.9\ N$$

$$T_o \geq 0.41\ Nm$$

Victor Prado

Research – Torque Calculations



With two minimum points of contact from the end effector, the force required to hold the sample without losing grip:

$$F \geq \frac{mg}{2\mu_s}$$

Output torque requirements are determined from the minimum force needed to hold the sample:

$$T_o \geq Fr_pFoS$$

Required contact force and output torque were computed using coefficients of static friction comparable to the fingertips and rock sample, maximum sample mass, gravity, and a factor of safety:

$$F \geq 7.1 \text{ N}$$

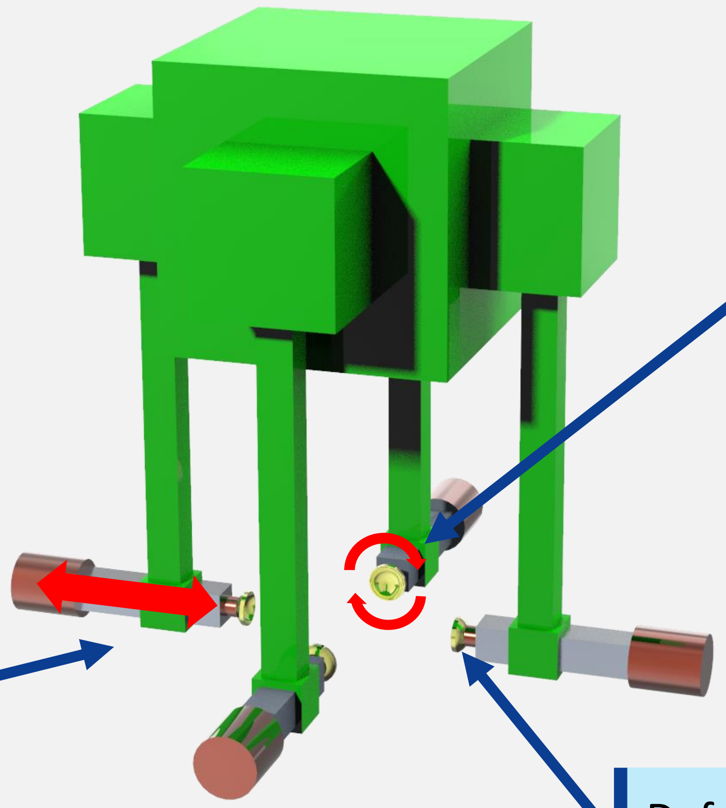
$$T_o \geq 0.15 \text{ Nm}$$

Victor Prado

End Effector: Overview

Design Goals

Securely hold and rotate sample in order to expose its entire surface to sensors



One pair of fingers translates inwards to grip sample, then rotates

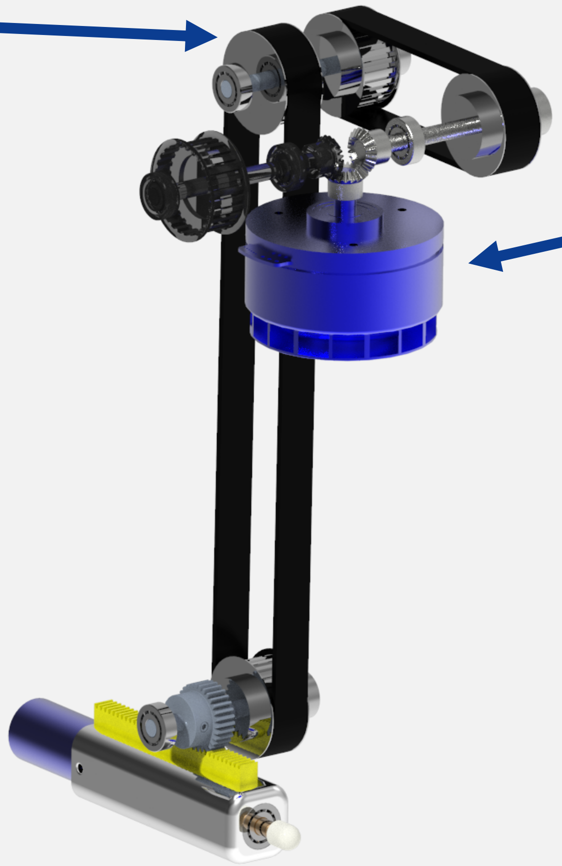
Only one pair of fingers will activate at once, switching to the other pair to rotate around another axis

Deformable tips to ensure good grip on sample

Victor Prado

End Effector: Detailed Design

Chain drive will be used in place of belts to reduce tension and wear issues

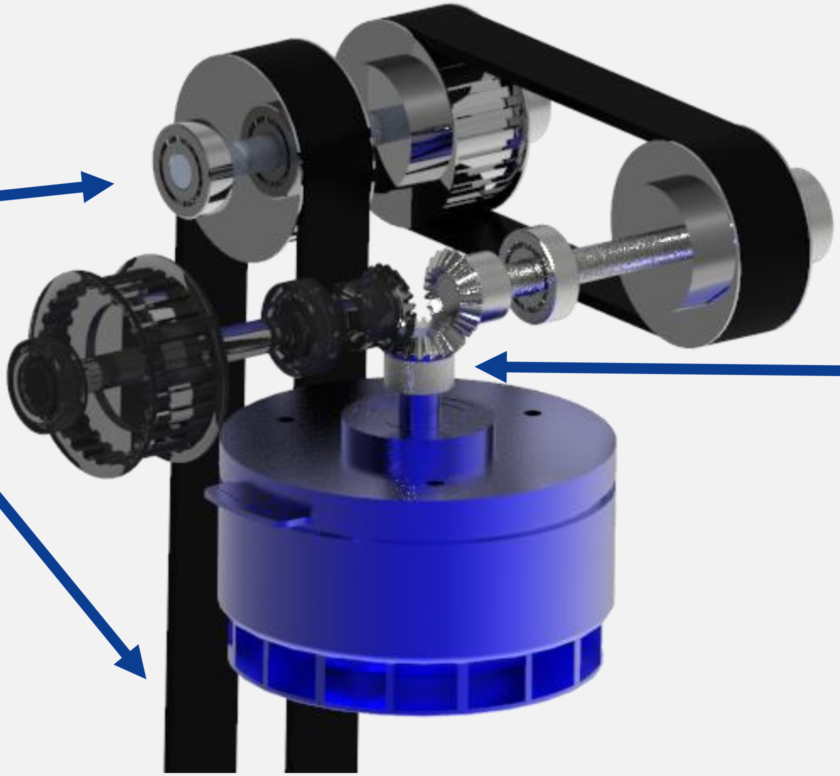


One motor is used to drive extension and contraction of 2 fingers which reduces weight

Victor Prado

End Effector: Detailed Design

Chains transfer power to the lower section of the end effector



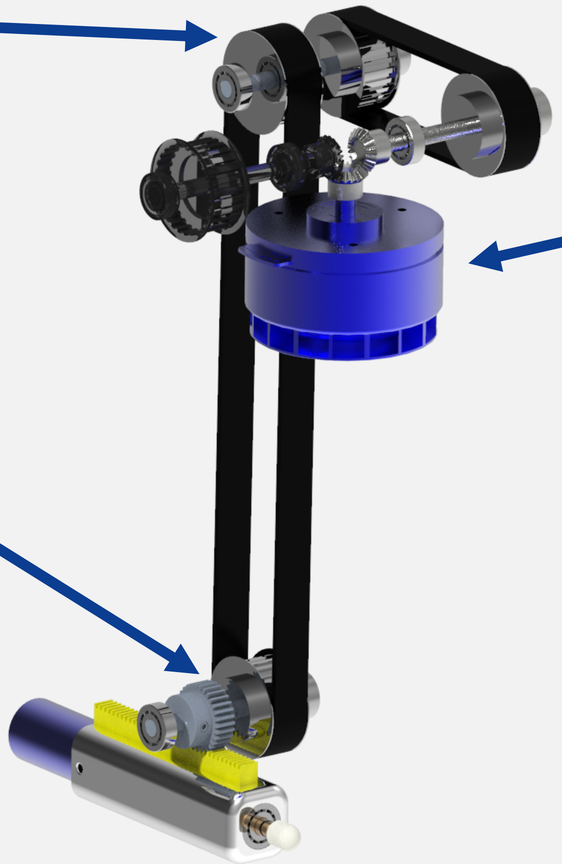
Bevel gears split the motor’s power two ways

Victor Prado

End Effector: Detailed Design

Chain drive will be used in place of belts to reduce tension and wear issues

One motor is used to drive extension and contraction of 2 fingers which reduces weight



Bevel gear, pinion, and chain pulley sizes will be selected once further torque analysis is complete

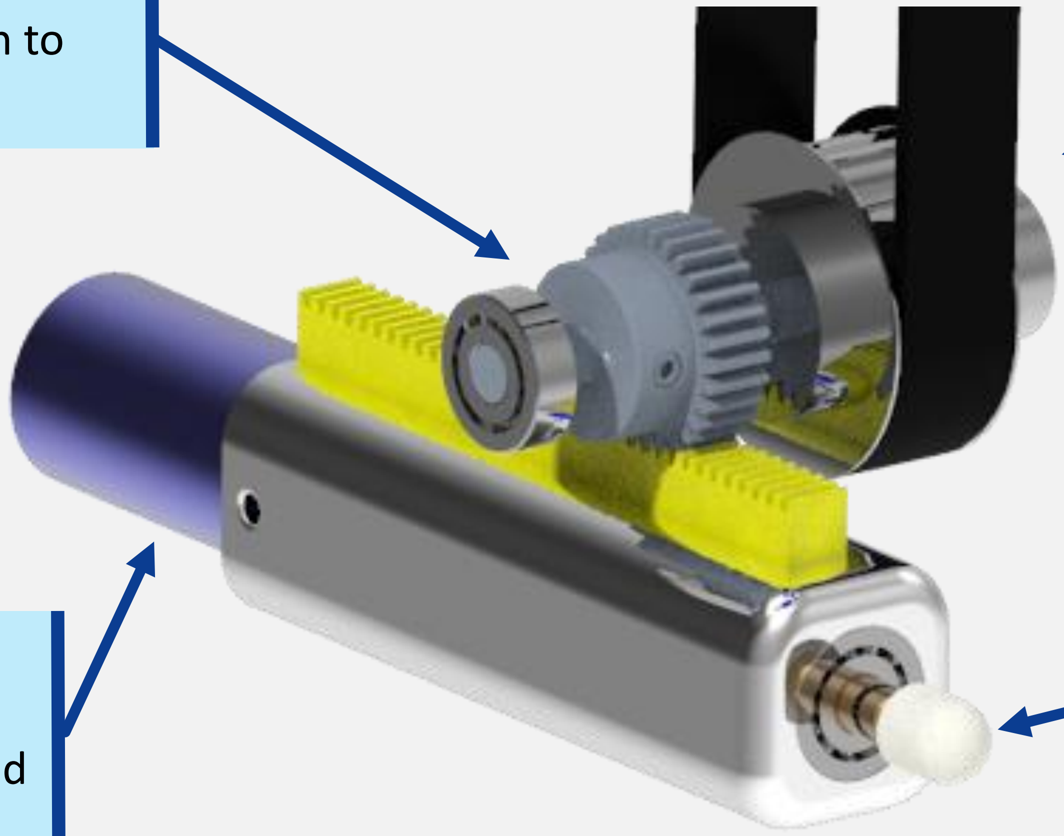
"Accordion" seals will be used around the back and front of the finger to reduce the need for complex rotational seals

Victor Prado

End Effector: Detailed Design

Rack and pinion transforms rotational motion to translational

Chains transfer power to the lower section of the end effector



Motor mounted to rear of finger, "flat" motor may be selected to reduce weight and size

Pliable finger tip deforms to ensure good grip of sample

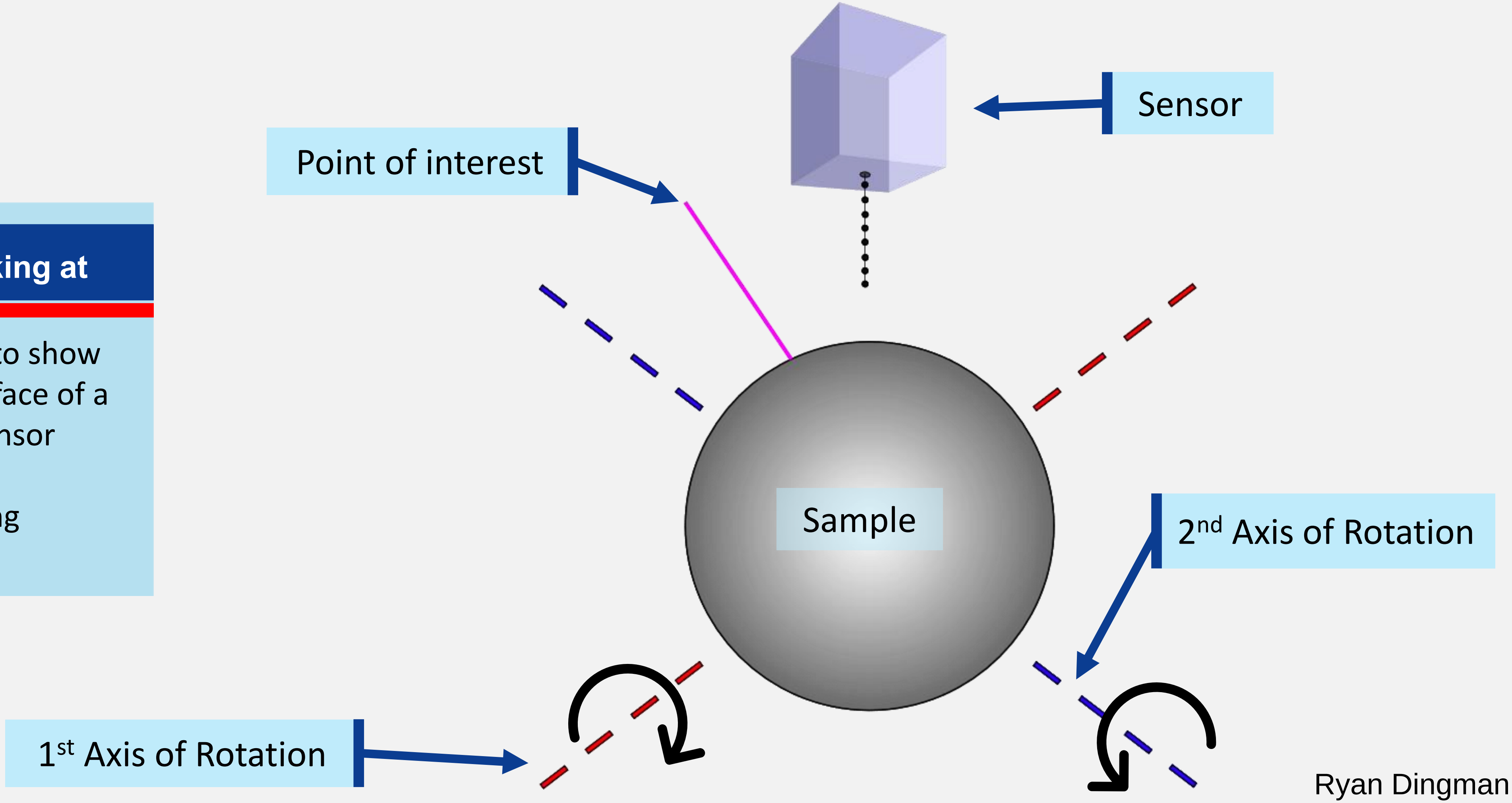
Victor Prado

Rotation Control

What you're looking at

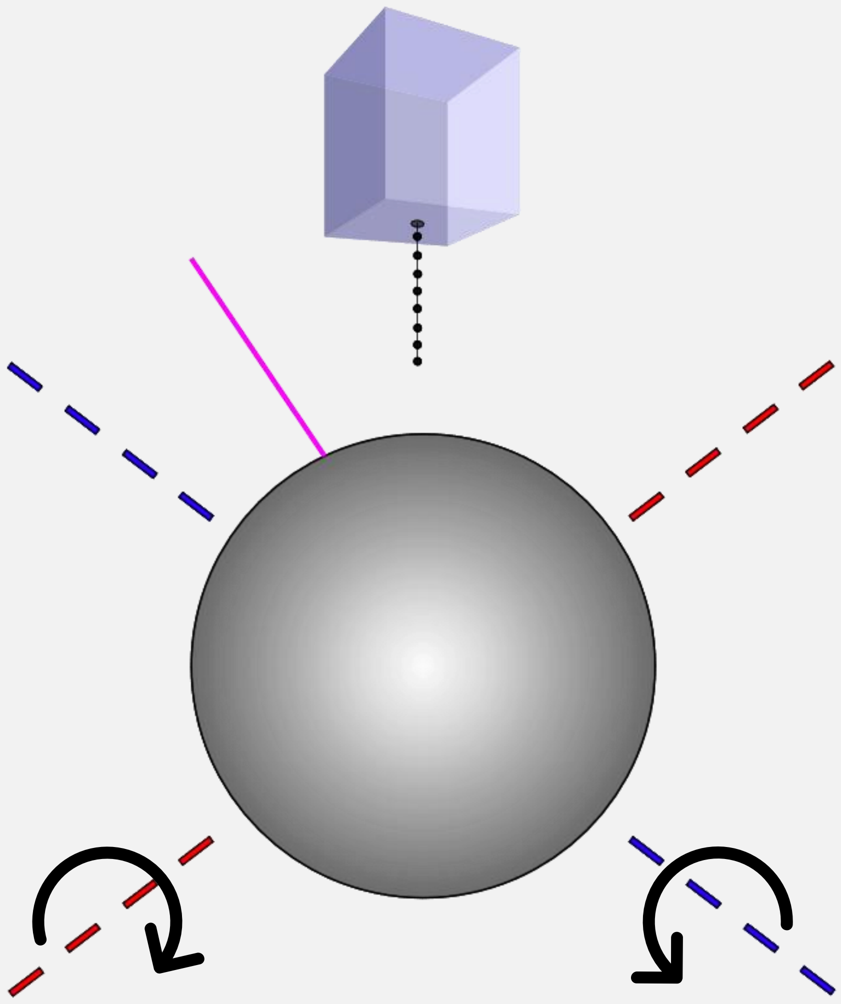
We want to be able to show any point on the surface of a sample to a fixed sensor

We do this by rotating around two axes



Ryan Dingman

Rotation Control



Steps to Rotating Point of Interest to Face Sensor

Rotate sample incrementally about 1st axis of rotation

Continuously perform rotation transformation calculations on Point of Interest

Stop rotation about 1st axis when Point of Interest intersects XZ-plane (or when y = 0)

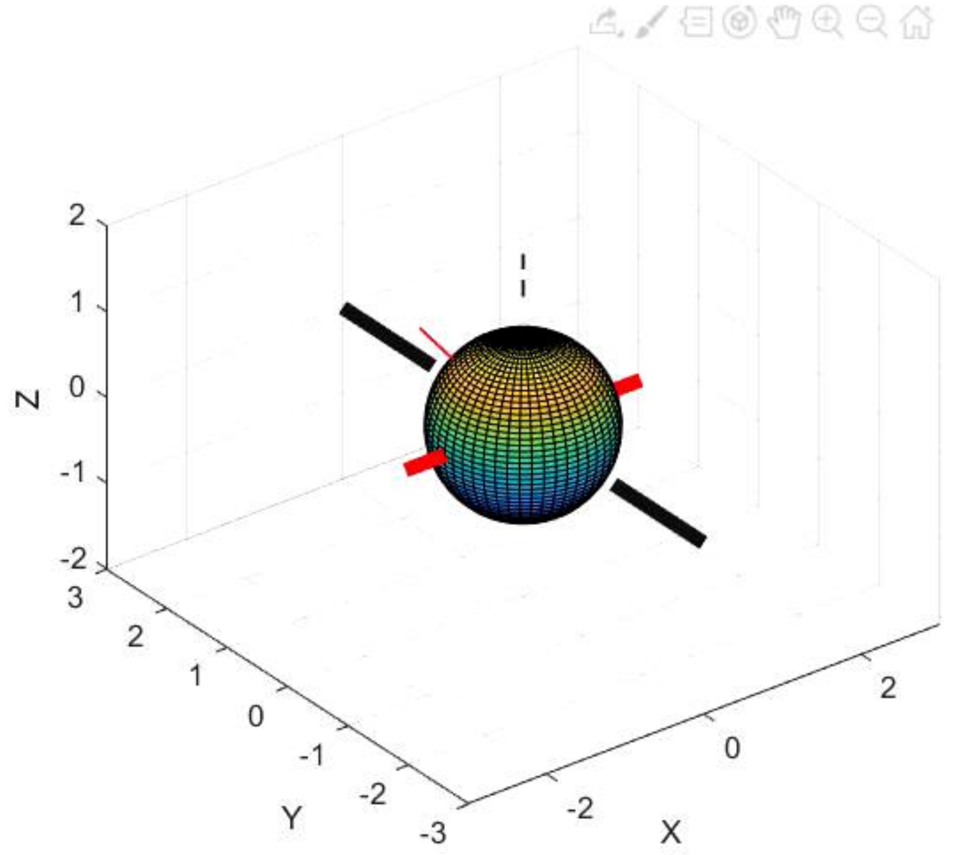
Second pair of fingers extends until it contacts sample

First pair of fingers then retracts to allow for 2nd rotation

Rotate sample about 2nd axis of rotation until Point of Interest intersects YZ-plane (or when x = 0)

Ryan Dingman

Rotation Control



Steps to Rotating Point of Interest to Face Sensor

Rotate sample incrementally about 1st axis of rotation

Continuously perform rotation transformation calculations on Point of Interest

Stop rotation about 1st axis when Point of Interest intersects XZ-plane (or when y = 0)

Second pair of fingers extends until it contacts sample

First pair of fingers then retracts to allow for 2nd rotation

Rotate sample about 2nd axis of rotation until Point of Interest intersects YZ-plane (or when x = 0)

Ryan Dingman

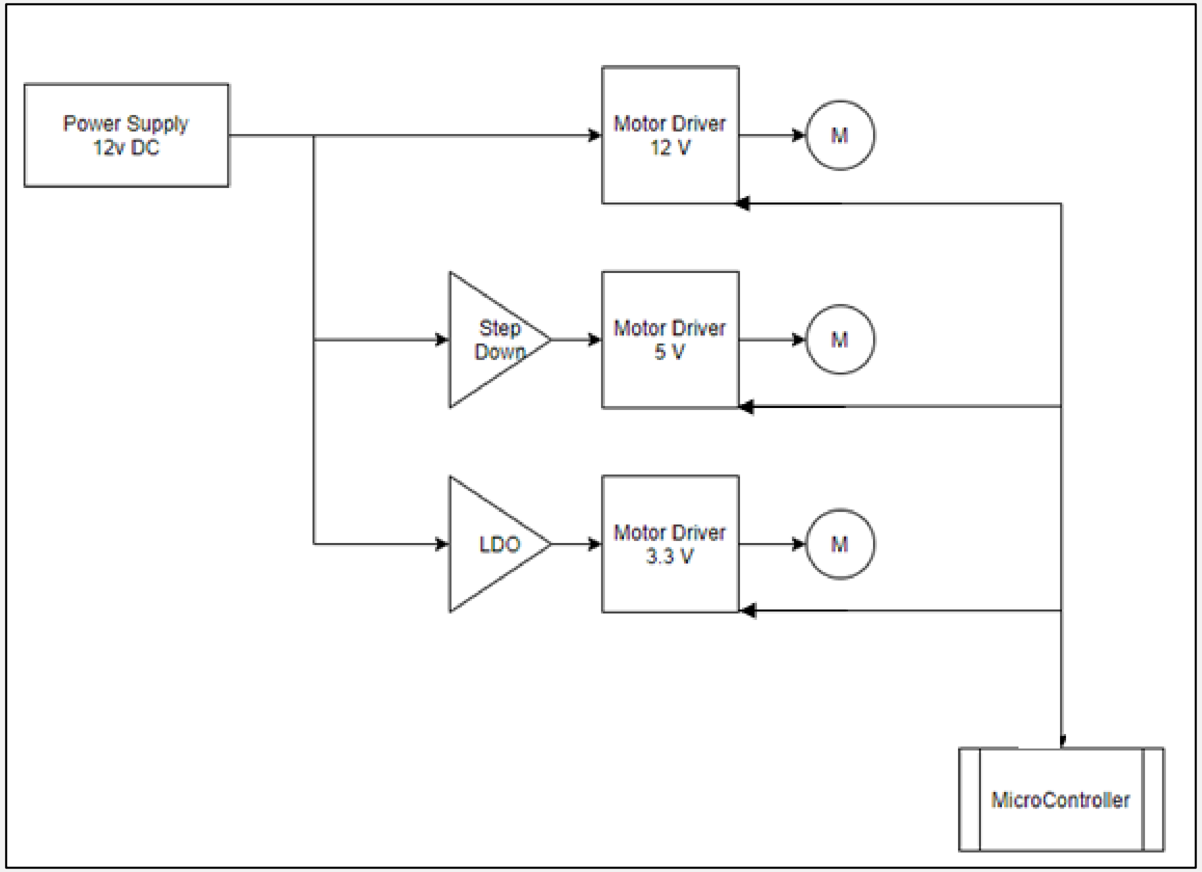
Electrical

Layout

DC-DC converters can be used to lower the voltage from the source to supply power to lower voltage motor drivers

Using LDO's and direct connection from the motor driver to the source are also possible depending on the motor driver requirements

The communication channels from the motor drivers will be attached to a microcontroller



Ryan Dingman

Future Work

Finalize End Effector Design	Order Parts	Finalize Other Designs	End Effector Prototype
• Complete CAD • Complete drawings for machined parts • Decide on materials for each part	• Complete bill of materials • Determine where to order from • Place orders for all parts	• Finalize arm design, CAD and drawings • Finalize storage design, CAD, and drawings • Initial programming structure • Initial wiring diagrams	• Assemble final build • Finalize wiring • Finalize programming • Troubleshoot final build
2/3/2020 – 2/17/2020	2/17/2020 – 2/21/2020	2/21/2020 – 3/6/2020	After parts come in – Senior Design Day

Ryan Dingman

Team 517
Sample On-Boarding and Orientation

February 6, 2020

Justin Bomwell
Victor Prado
Ryan Dingman
Kalin Burnside
Joshua Jones
Matthew Schrold

Overview

Research

Detailed Design

Future Work