

Hardware in Loop 1/5

Scale Automobile



David Gordon | Chet Iwuagwu | Micah Hilliard |
Richard Allen | Nicholas Muoio | Kathleen Bodden

TEAM 503

Team 503



Richard Allen

Design Engineer



Micah Hilliard

Structural Engineer



Nich Muoio

Controls Engineer



David Gordon

Hardware Engineer



Chet Iwuagwu

Software Engineer



Kathleen Bodden

Research/Test Engineer

Stakeholders



Central Intelligence Agency



FAMU-FSU College of Engineering



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FAMU-FSU College of Engineering*



*Camilo Ordoñez
FAMU-FSU College of Engineering*



*Christian Hubicki
FAMU-FSU College of Engineering*

Objective



Objective



AME Building

Objective

 Integrate with Team 504



Objective



🔑 Integrate with Team 504

🔑 Full Autonomy

Objective



🔑 Integrate with Team 504

🔑 Full Autonomy

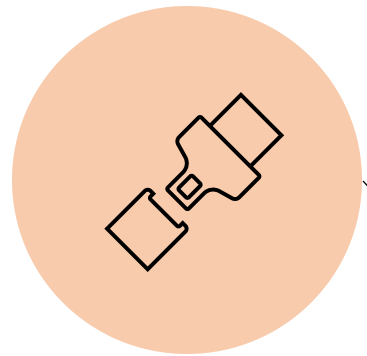
🔑 Maintain Velocity

Objective

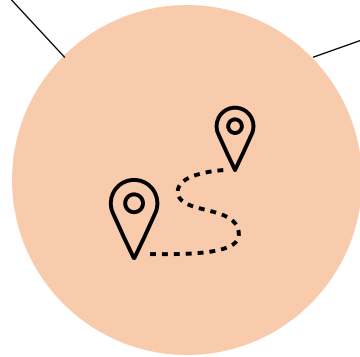


- 🔑 Integrate with Team 504
- 🔑 Full Autonomy
- 🔑 Maintain Velocity
- 🔑 Minimize inertial losses

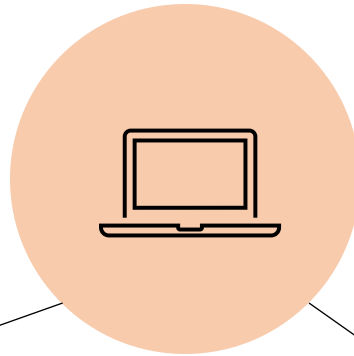
Essentials



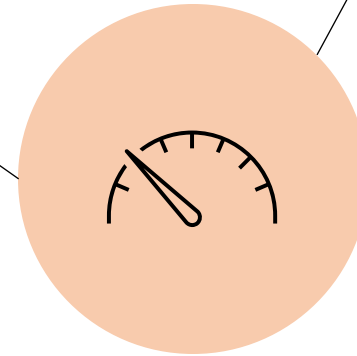
Safety & Stability



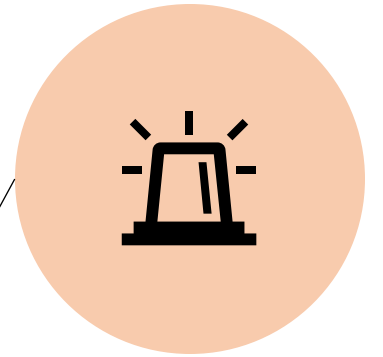
Determined Path



Simulations

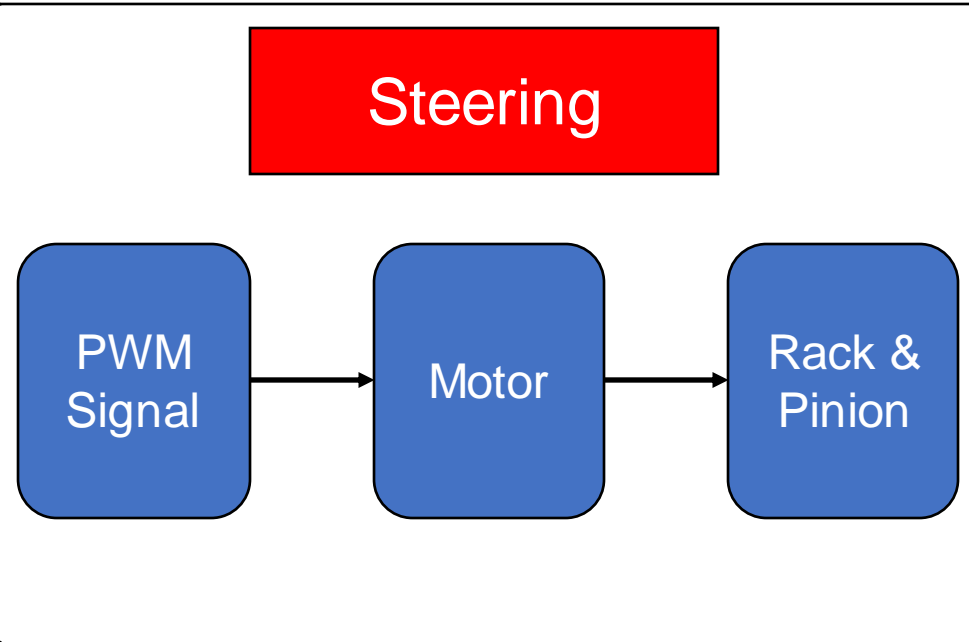


Velocity

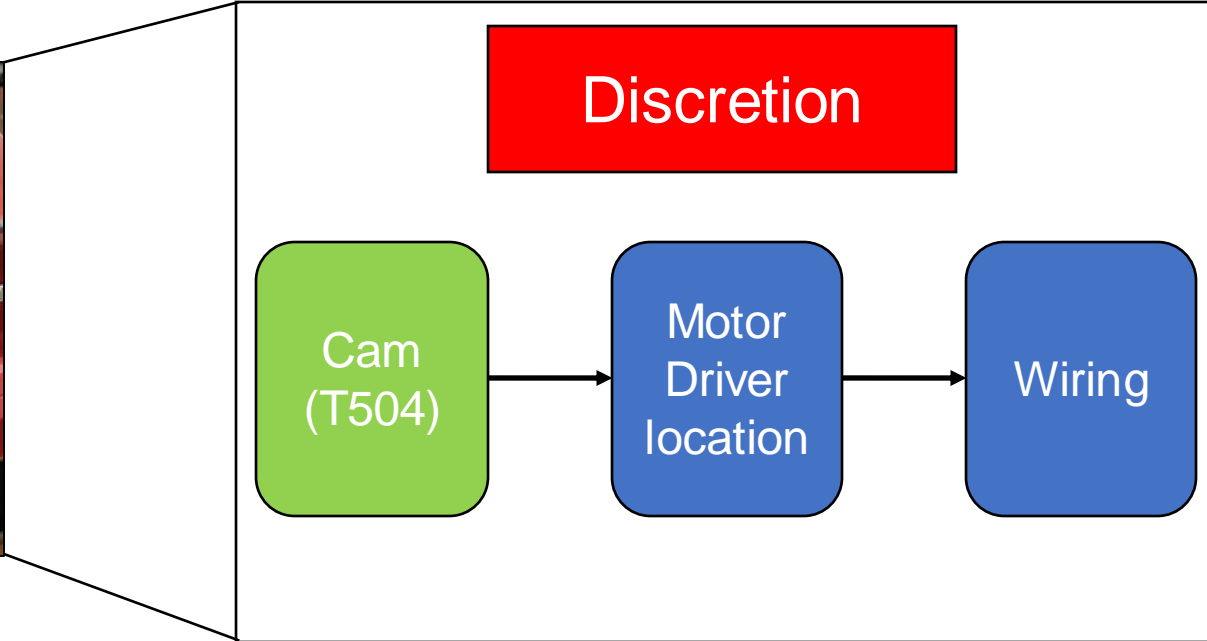


Emergency Stop

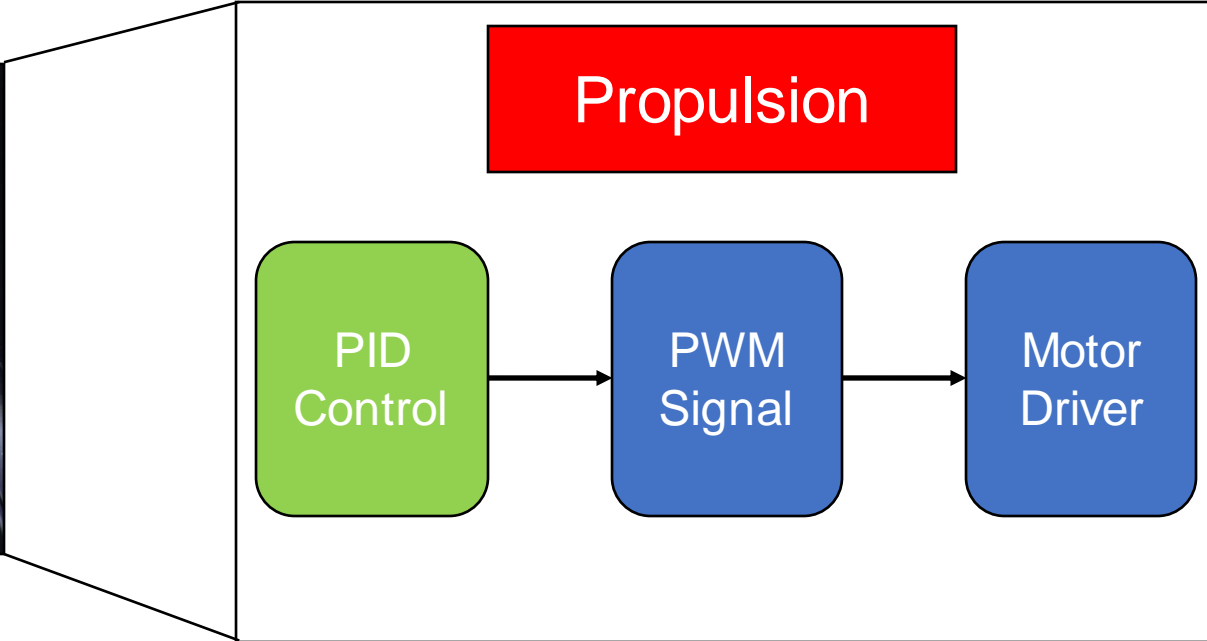
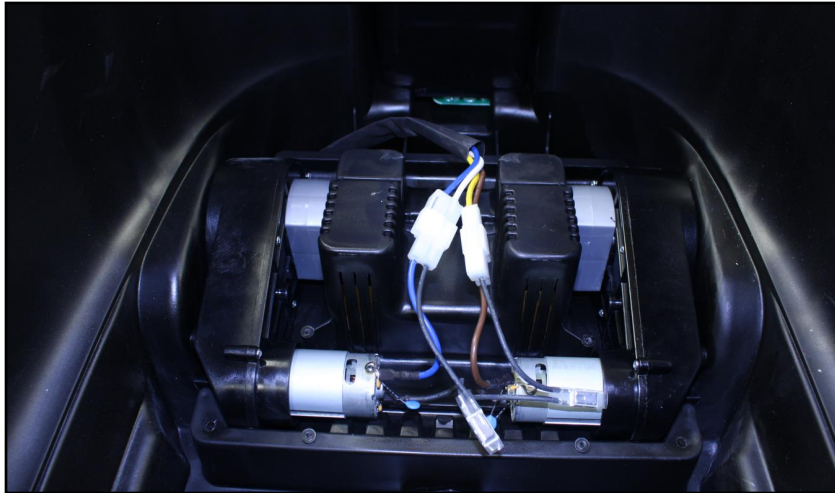
System Breakdown



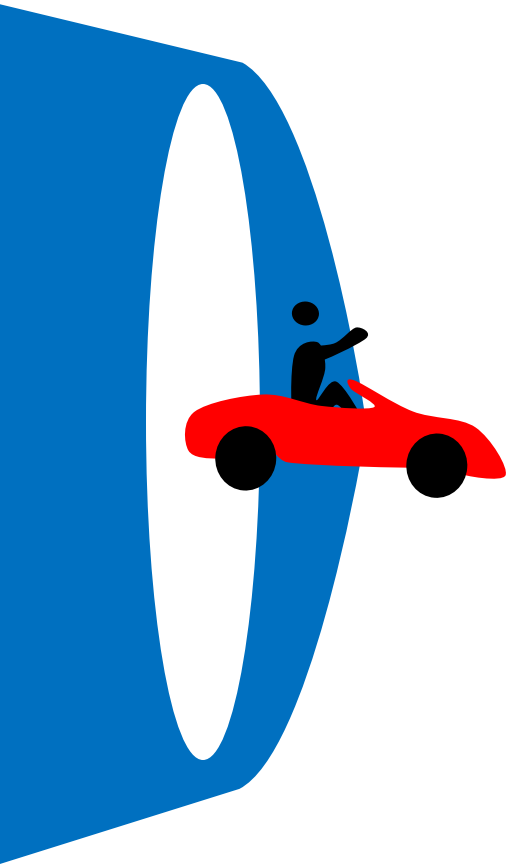
System Breakdown



System Breakdown



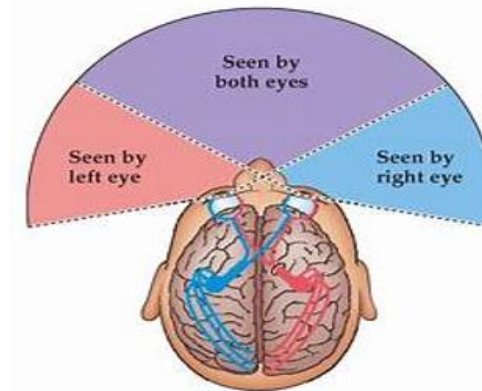
Overall Design



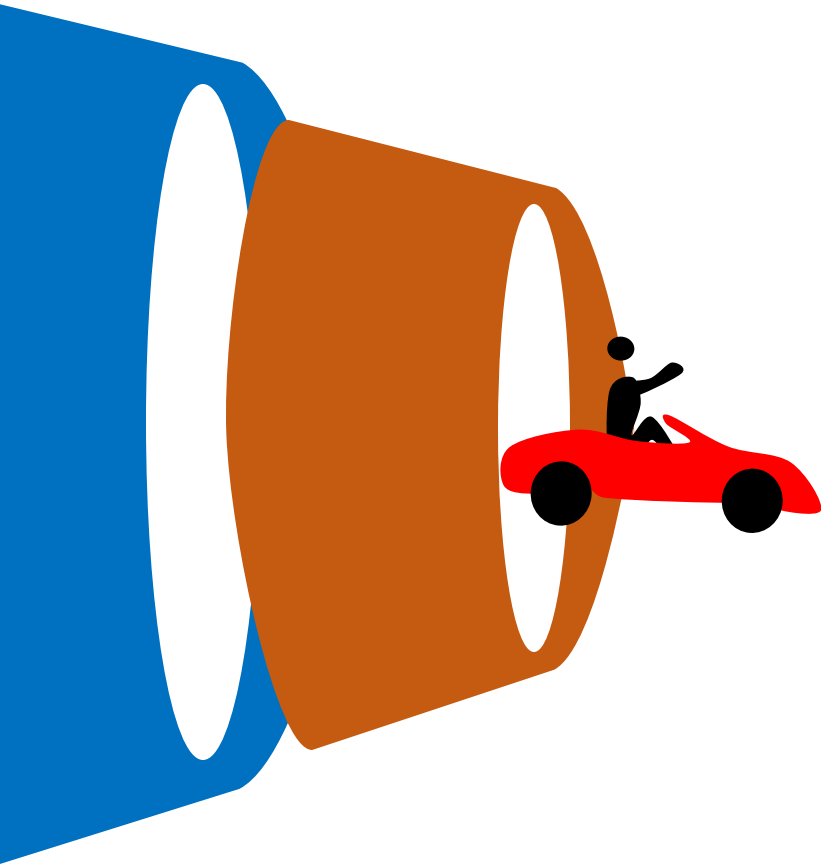
Morphological Chart

	IDEA 1	IDEA 2	IDEA 3
STEERING	Ackermann	Differential	Omnidirectional
SOFTWARE	ROS 1	ROS 2	-
PATHING	Model Predictive Control + PID	Sample Based Model Predictive Optimization	Genta
BRAKING	Resistive	Regenerative	Reverse

Camera placement :



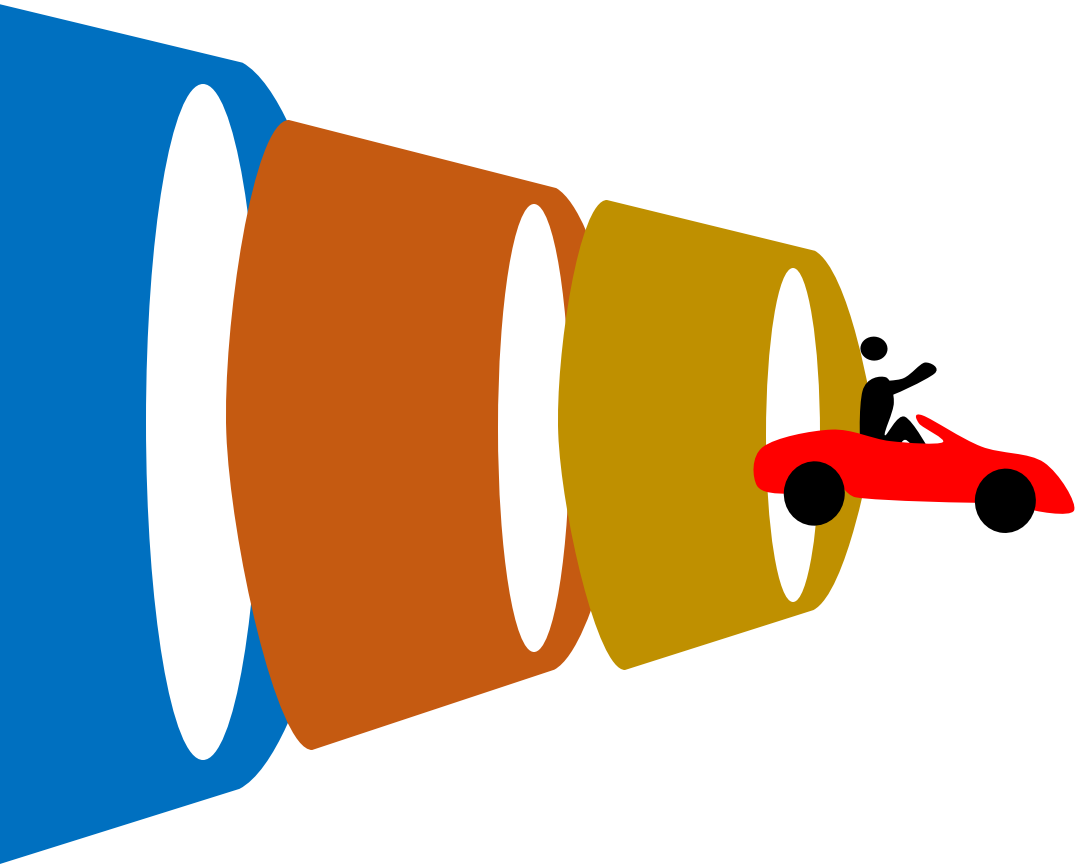
Overall Design



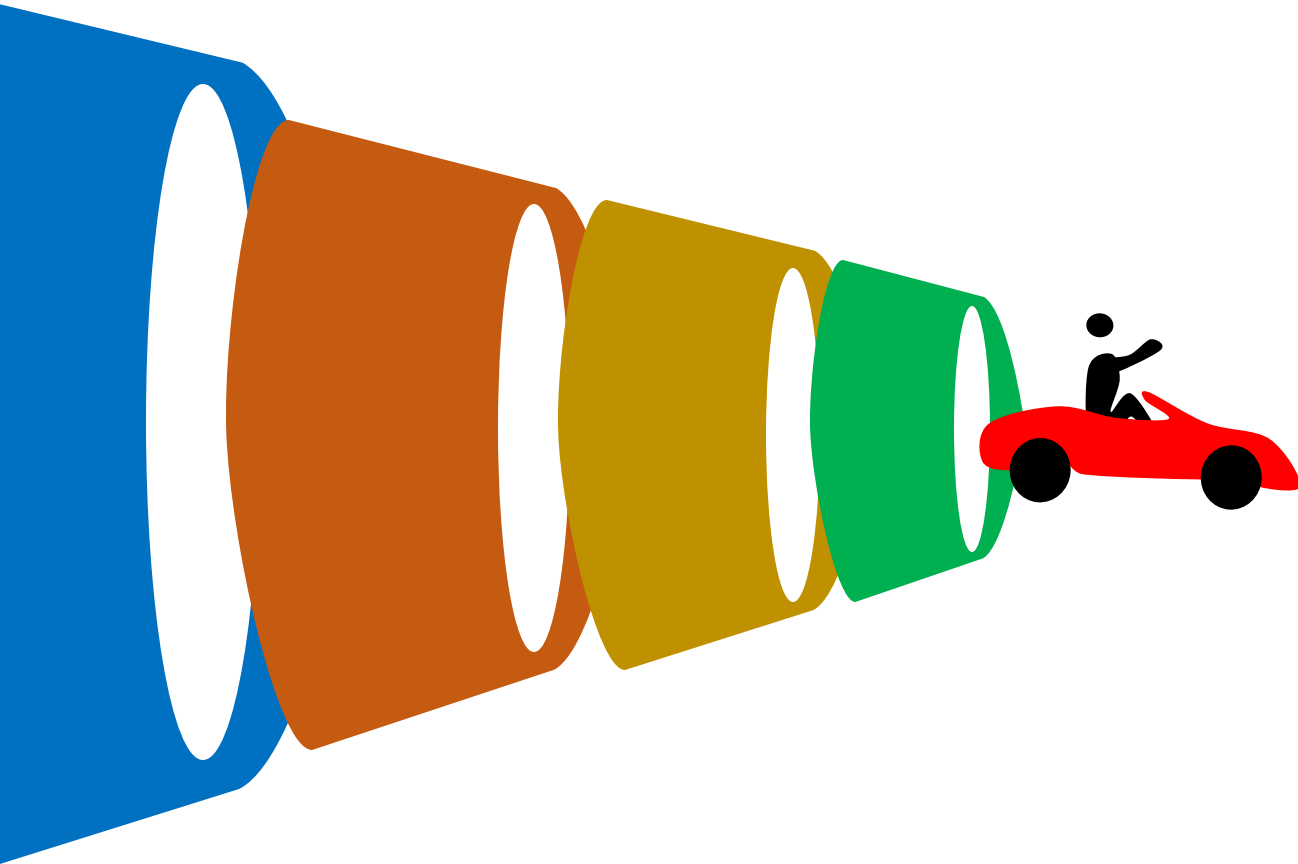
Engineering Characteristic ranking based on customer requirements:

1. Maintain velocity
2. Simulation Runs
3. Measure tire speed

Overall Design



Overall Design



Final Design:

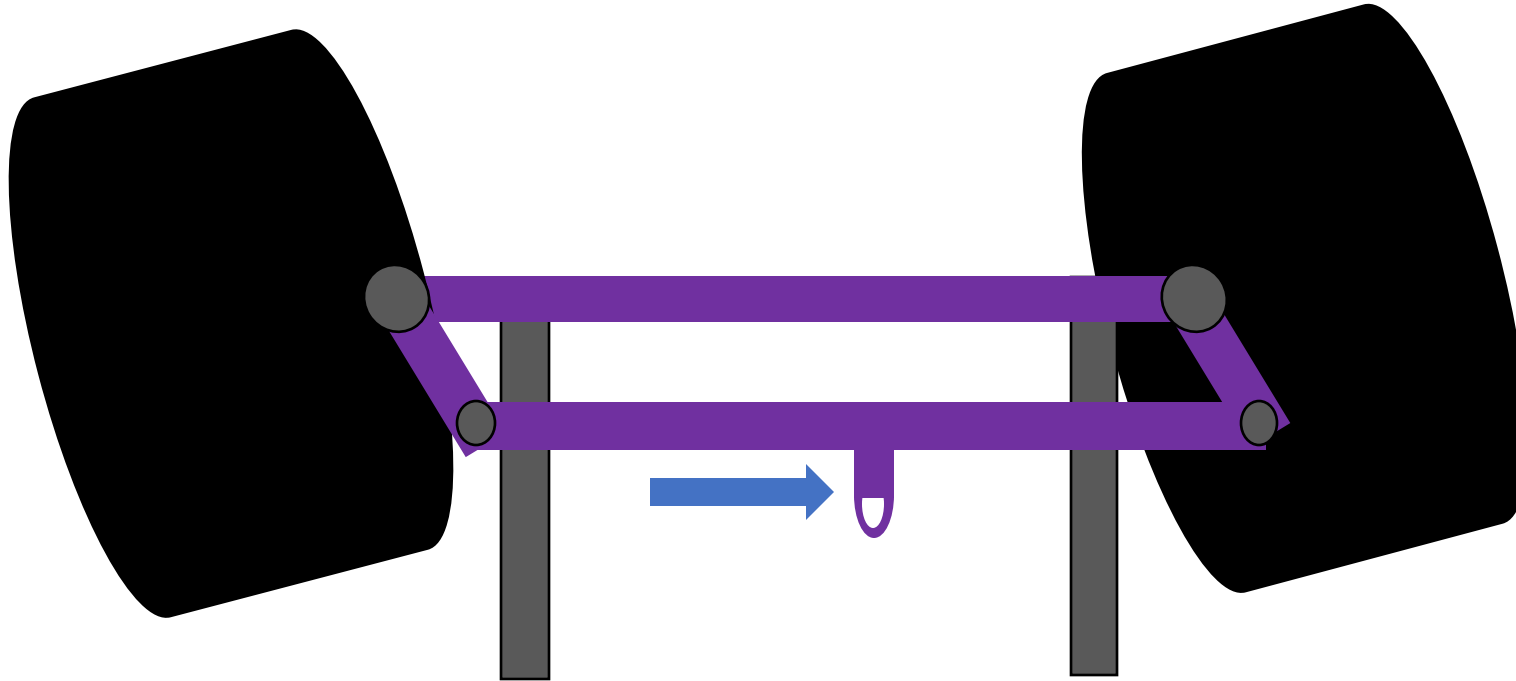
Ackermann Steering

ROS2 Software

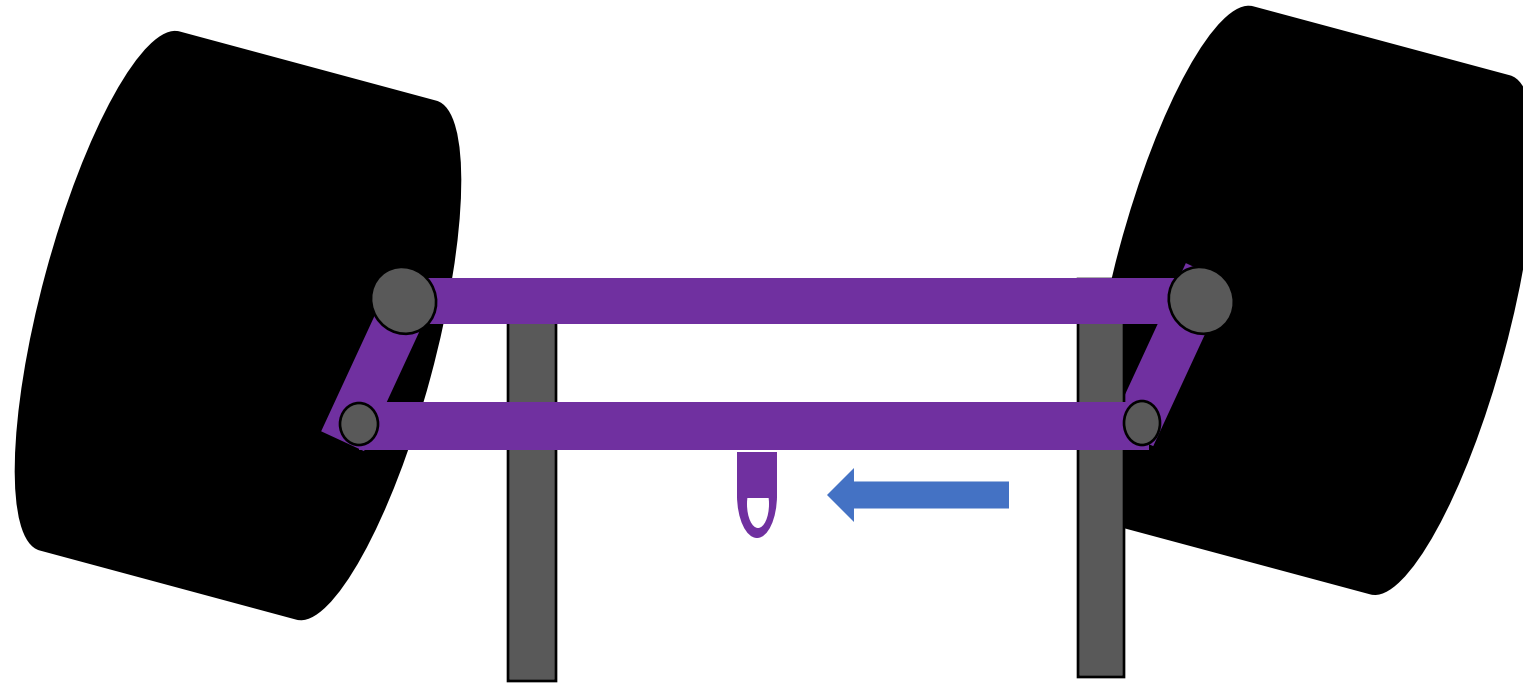
Model Predictive + PID Control

Regenerative Braking

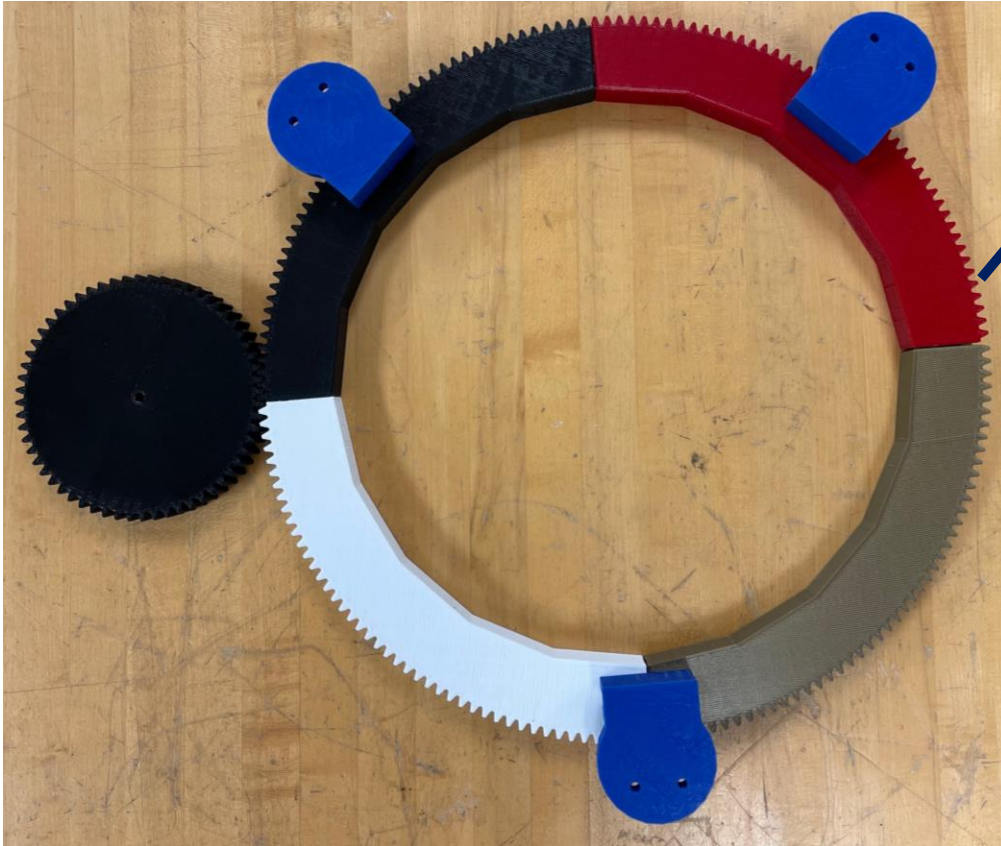
Steering Actuation



Steering Actuation



Steering Actuation – Initial Design



1.8 degrees of motion

Machine Guarding

Steering Actuation – Final Design

$$F_R = m_{SA}g\mu_s + m_{SA}a_{SA} + F_e$$



Steering Actuation – Final Design



$$F_R = m_{SA}g\mu_s + m_{SA}a_{SA} + F_e$$

Where:

$$F_e = F_N\mu_p$$

$$F_N = m_Cg$$

$$\mu_p = 0.3$$

$$\mu_s = 0.7$$

Steering Actuation – Final Design



$$F_R = m_{SA}g\mu_s + m_{SA}a_{SA} + F_e$$

Where:

$$F_e = F_N\mu_p$$

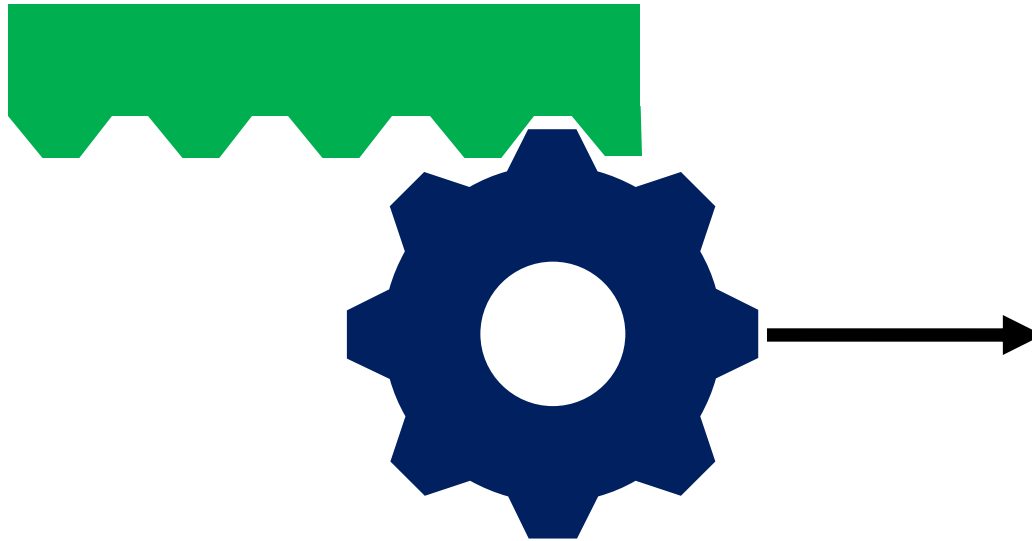
$$F_N = m_Cg$$

$$\mu_p = 0.3$$

$$\mu_s = 0.7$$

$$T_p = F_R r_p$$

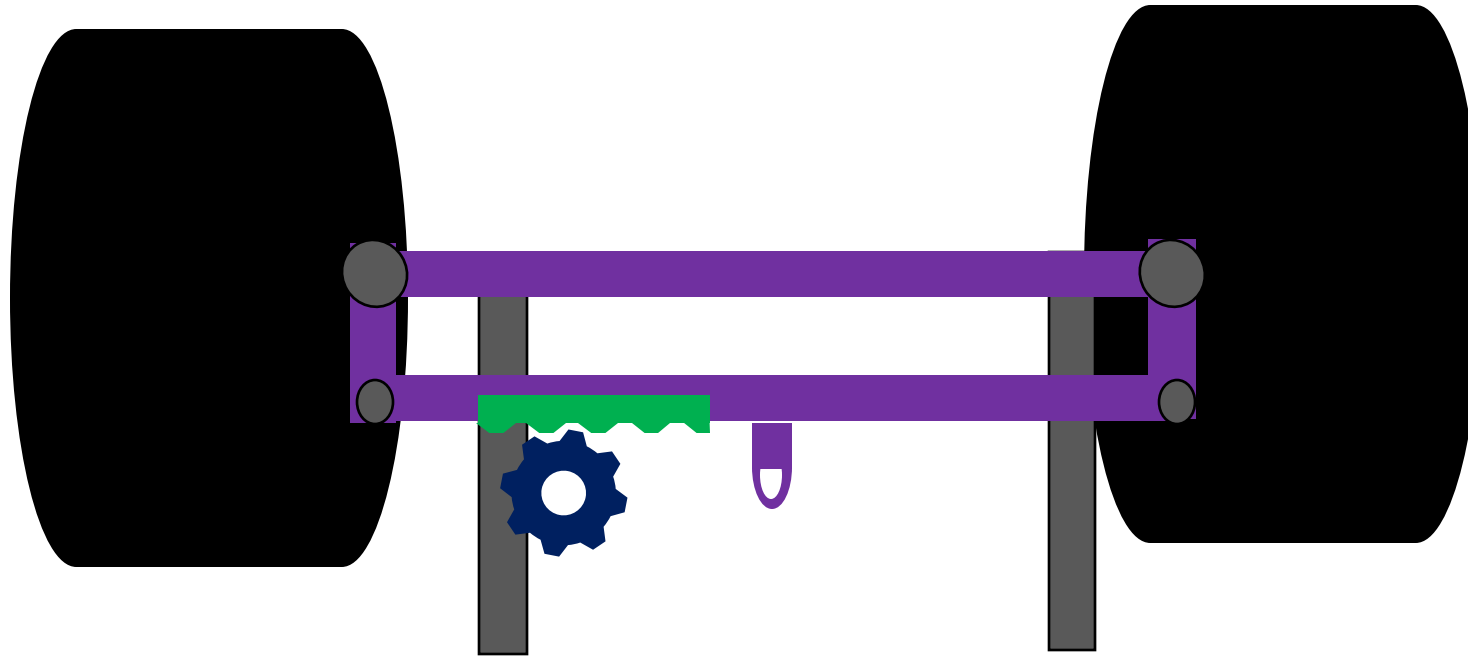
Steering Actuation – Final Design



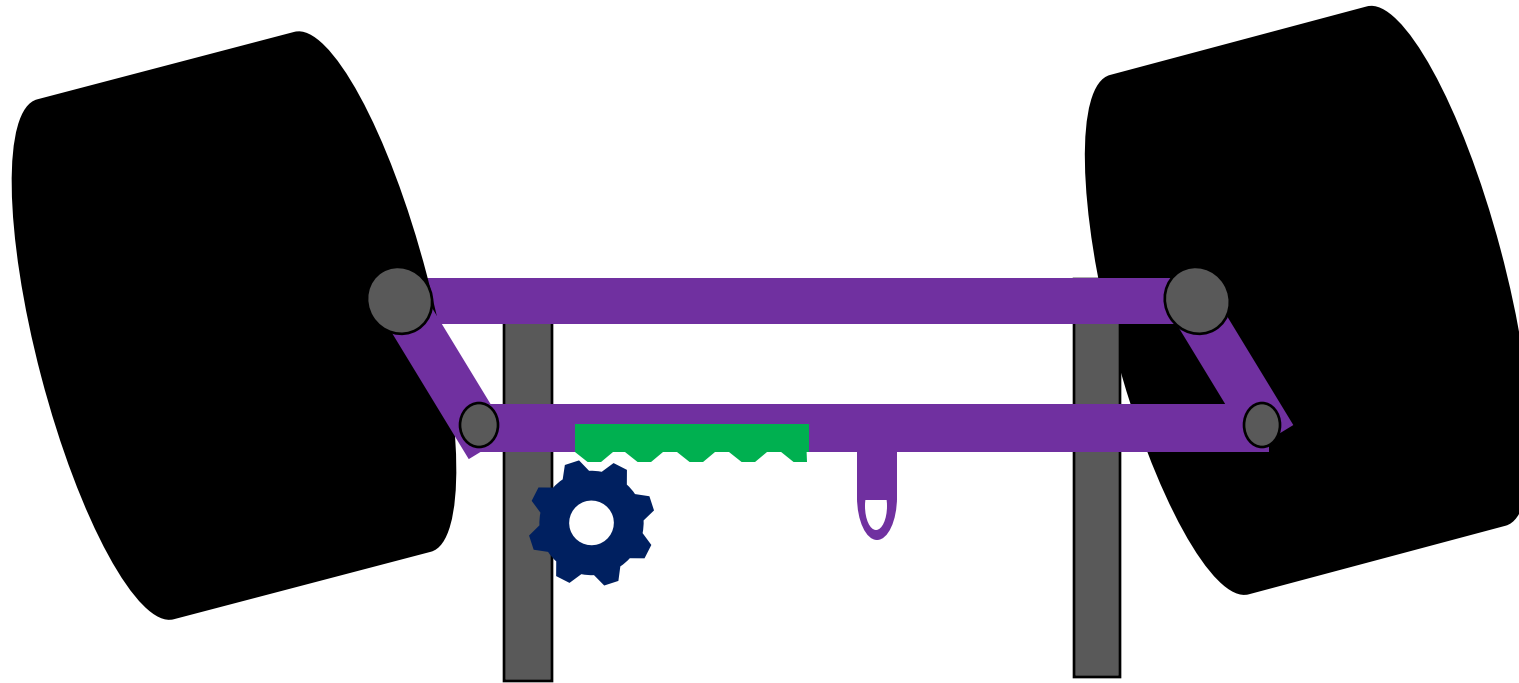
75:1 Metal Gearmotor
25Dx69L mm HP 12V
with 48 CPR Encoder



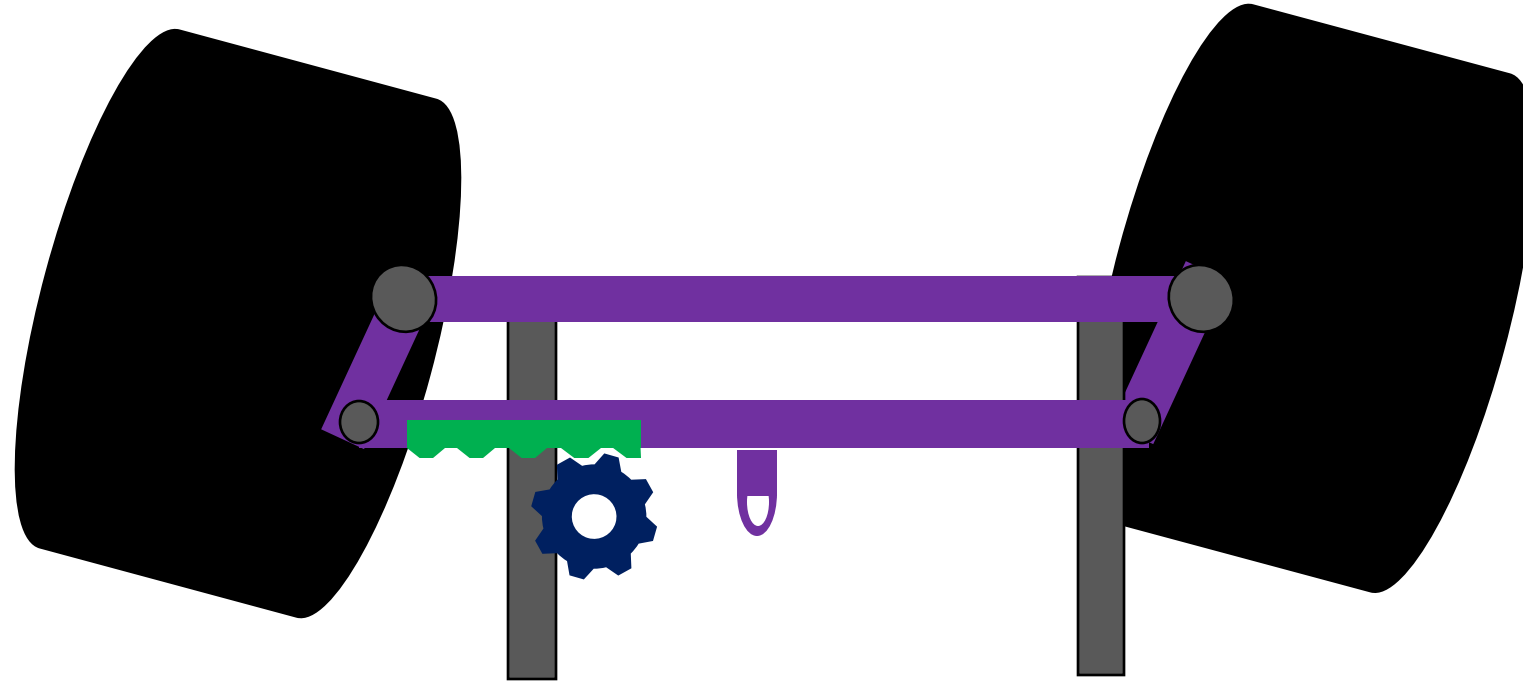
Steering Actuation – Final Design



Steering Actuation



Steering Actuation

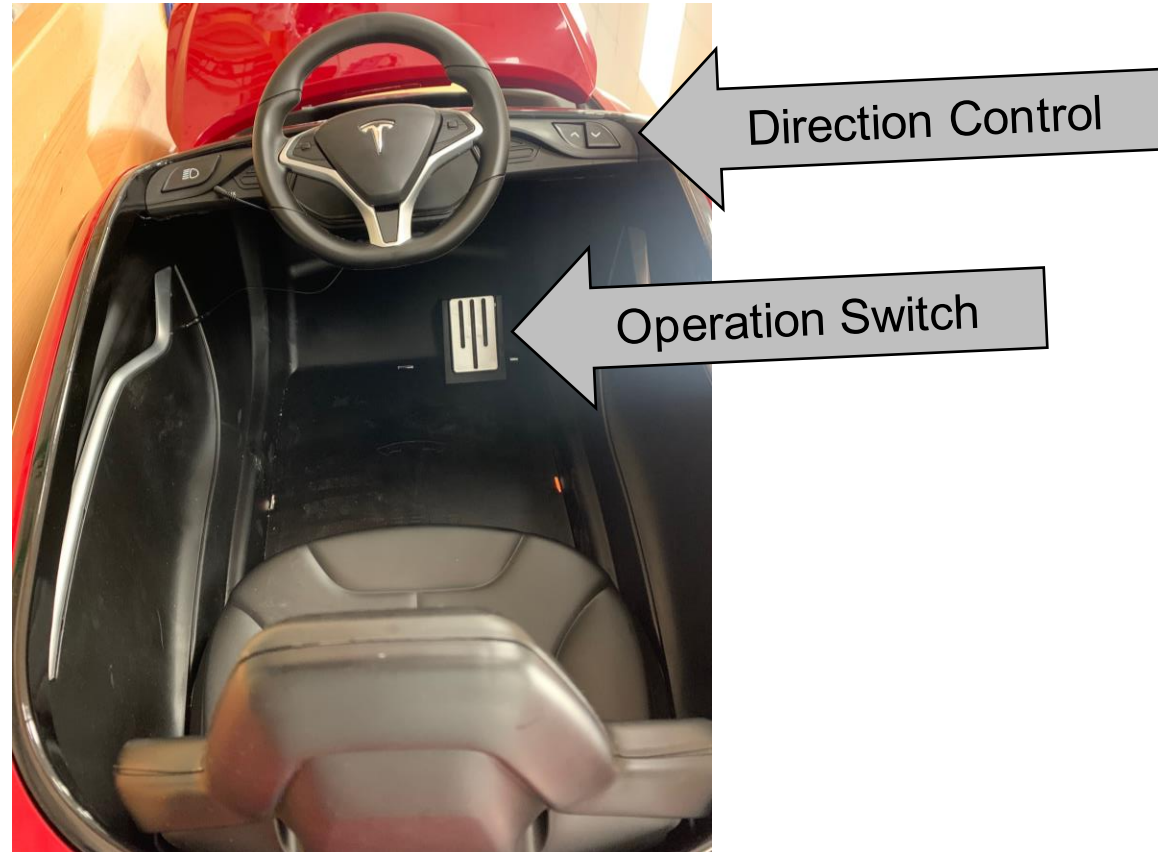


Steering Actuation – Lubrication

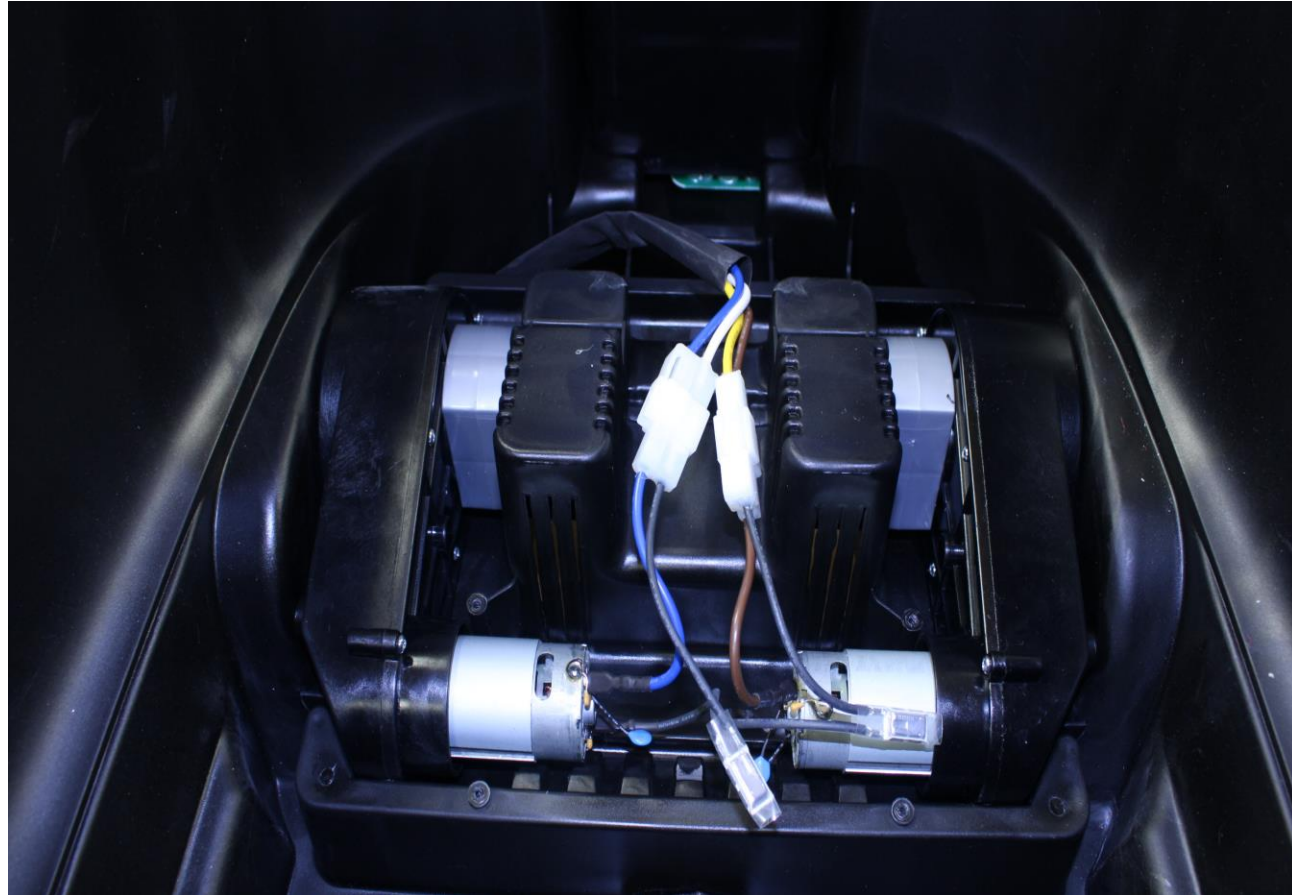
Multipurpose Grease: Lithium,
White, 16 oz, NLGI Grade 2,
120°F Max. Op Temp.



Propulsion



Propulsion

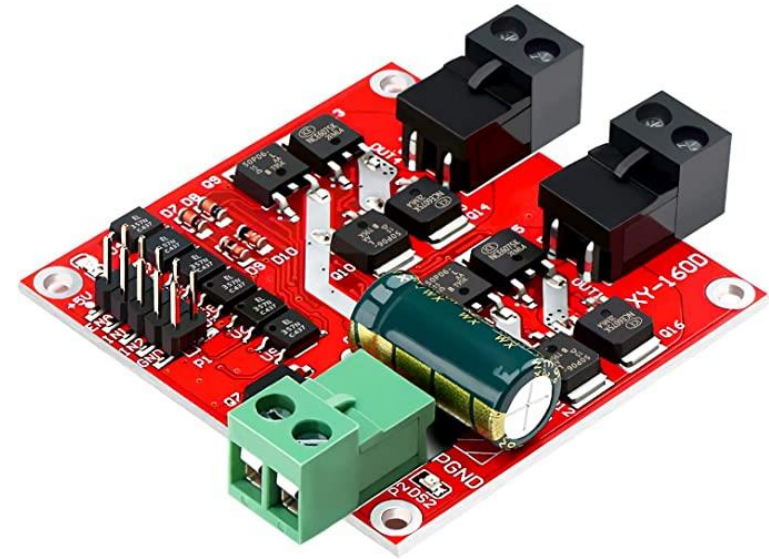


Propulsion



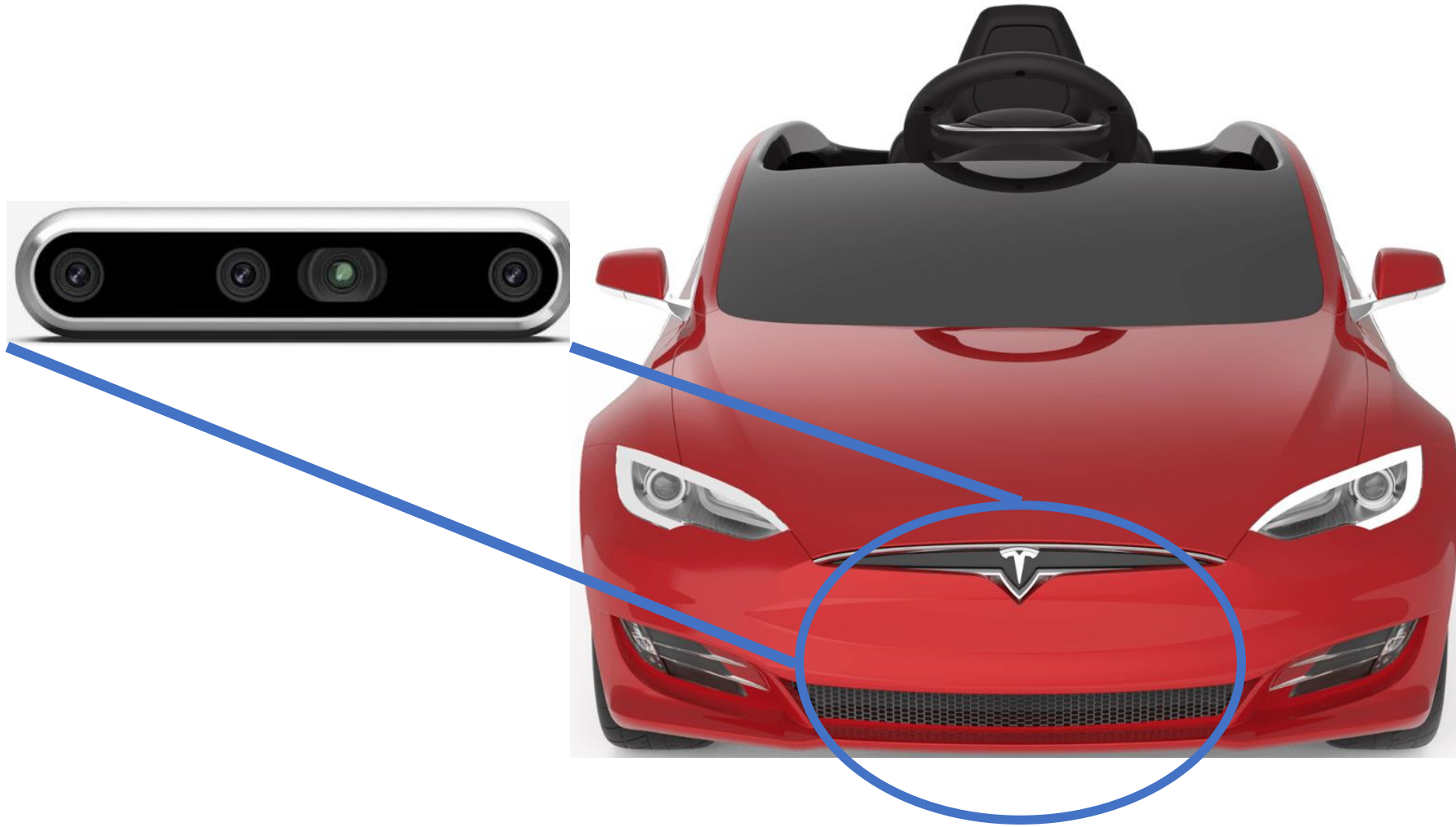
NVIDIA Jetson

+



DC Motor Driver
L298 Dual H Bridge

Discretion

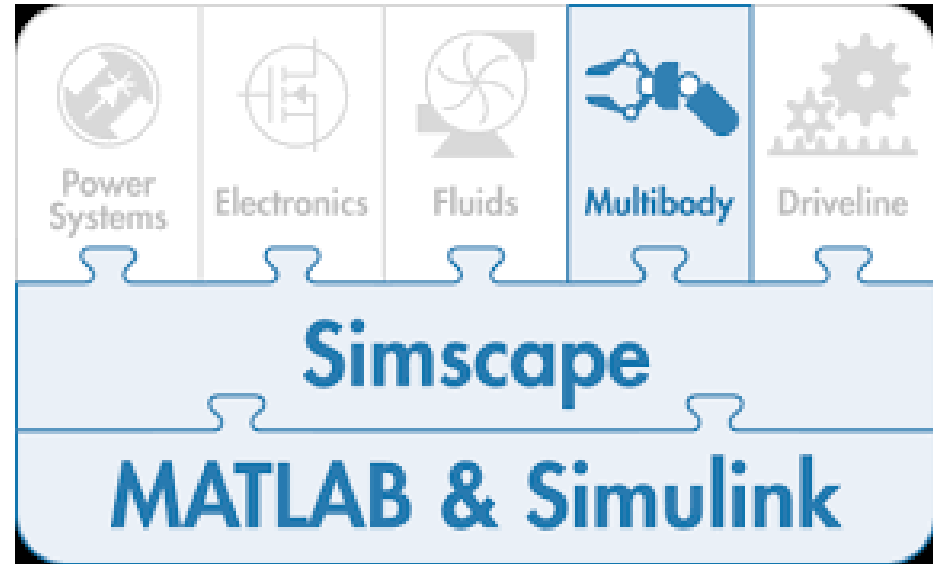


Discretion

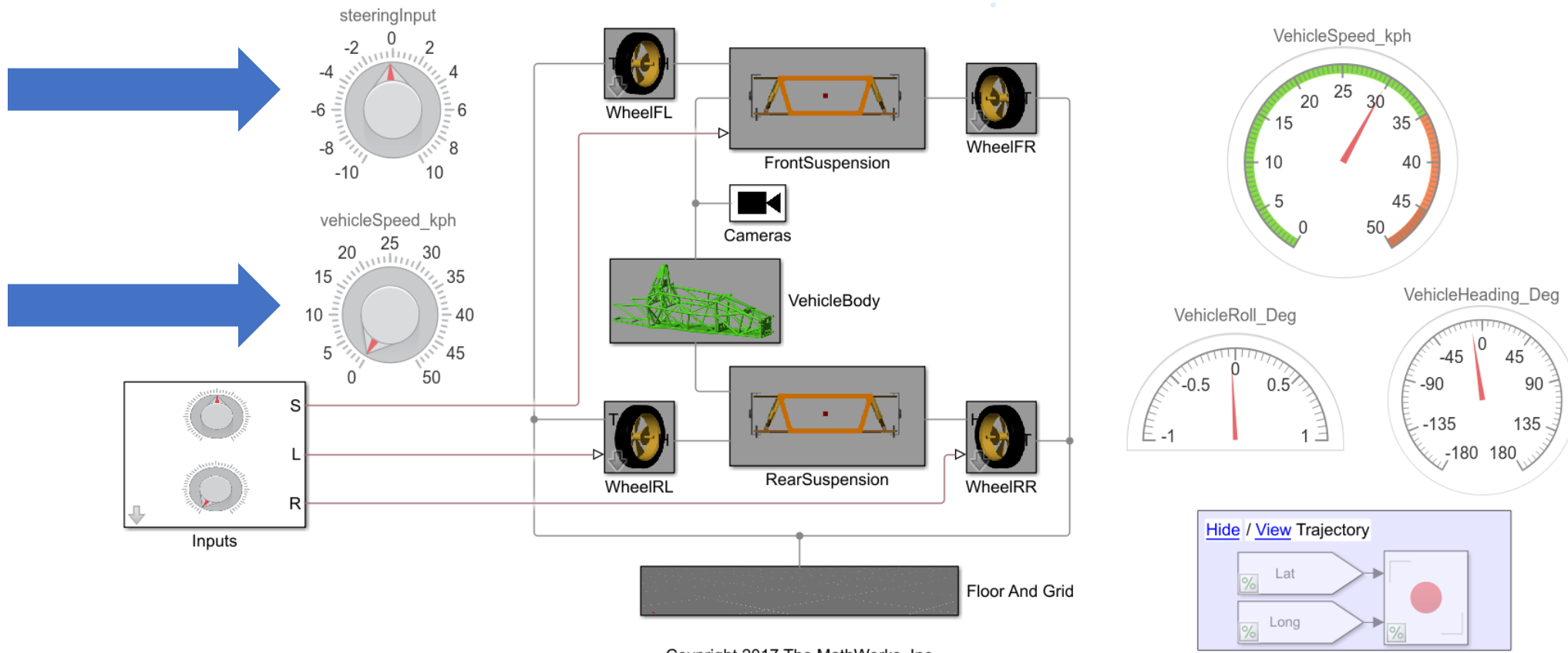
Setup frunk for
NVIDIA Jetson
wiring



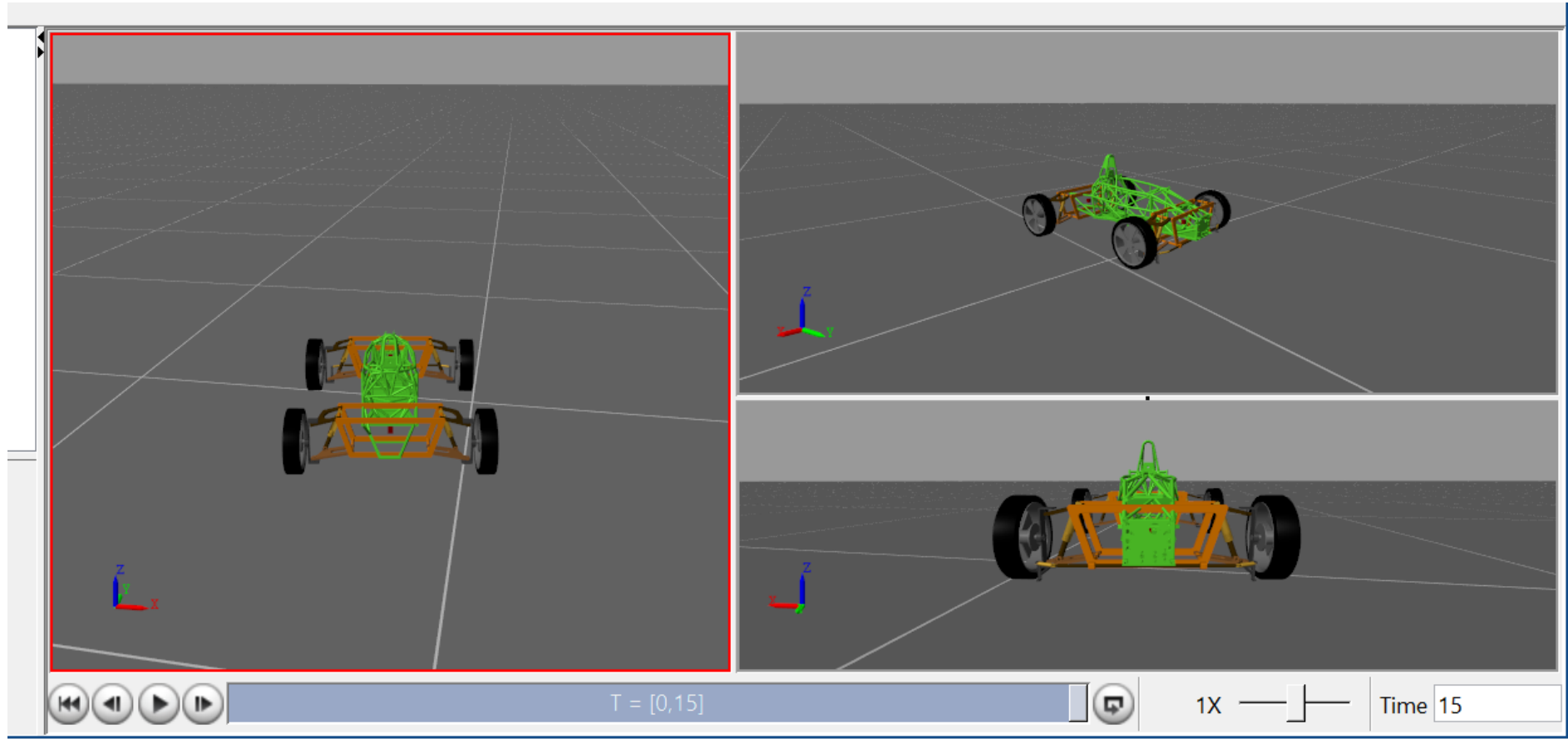
Controls / Simulations



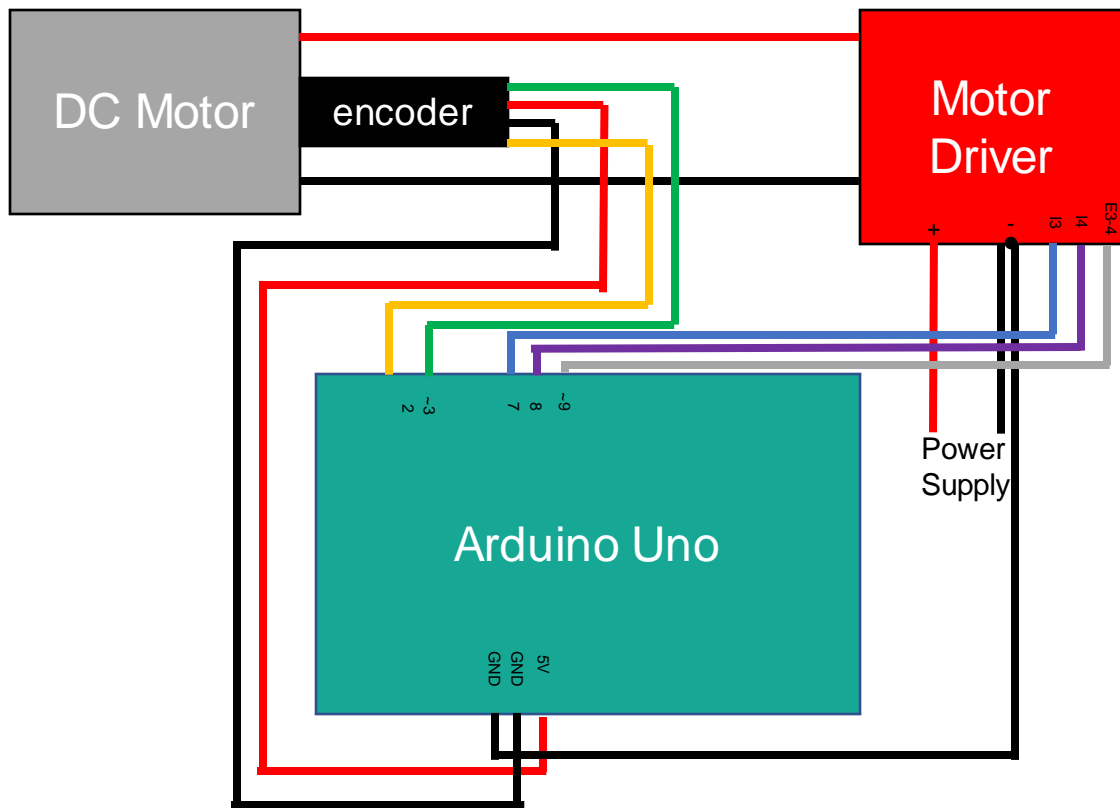
Controls / Simulations



Controls / Simulations



Controls / Simulations



```
// Define PID variables
double Setpoint, Input, Output;
double Kp = 2, Ki = 0.01, Kd = 0.1;
PID myPID(&Input, &Output, &Setpoint, Kp, Ki, Kd, DIRECT);

void setup() {
  // Initialize motor pins
  pinMode(motorPWM, OUTPUT);
  pinMode(motorDirForward, OUTPUT);
  pinMode(motorDirReverse, OUTPUT);

  // Set target speed
  Setpoint = 100;

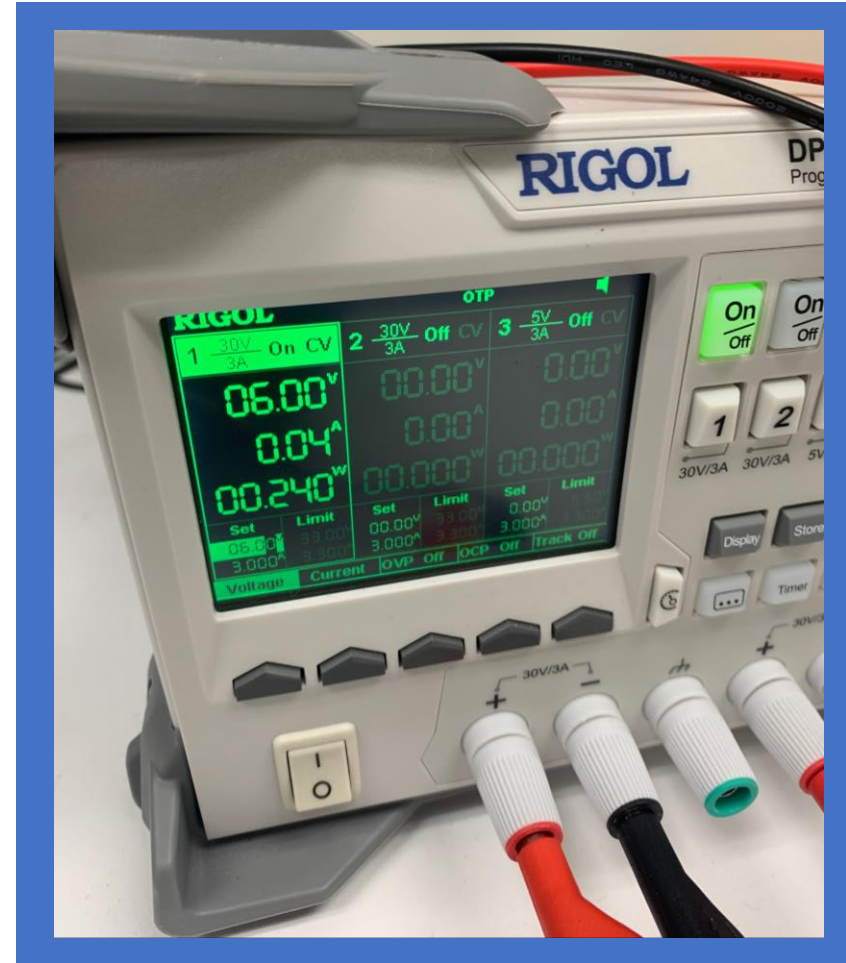
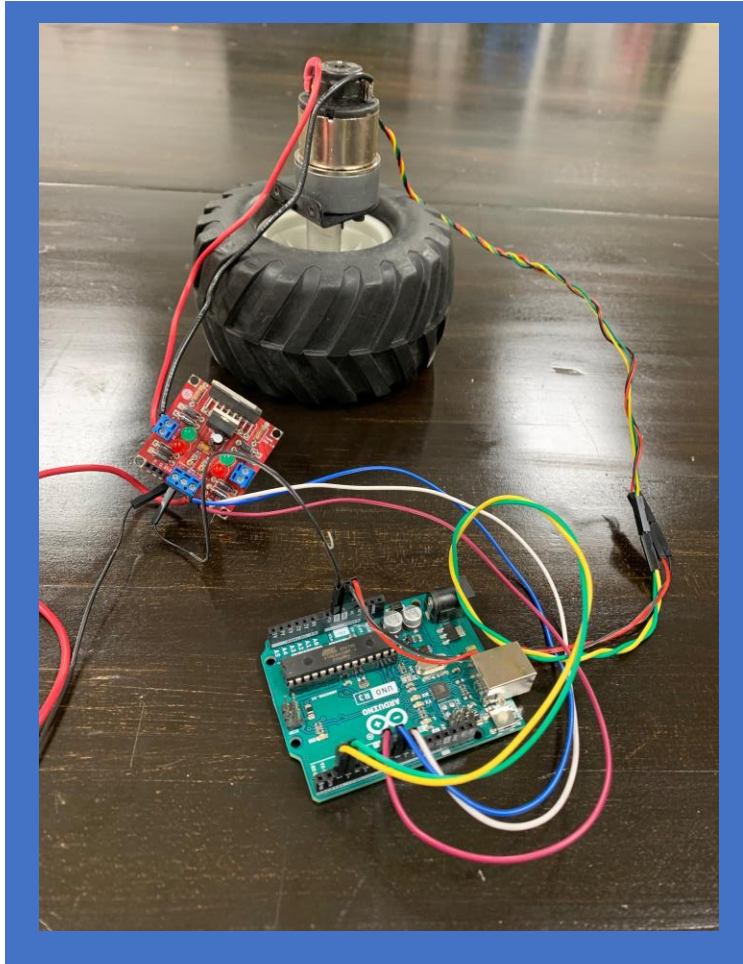
  // Set up PID
  myPID.SetMode(AUTOMATIC);
  myPID.SetOutputLimits(-255, 255);
}

void loop() {
  // Read encoder value
  Input = encoder.read();

  // Compute PID output
  myPID.Compute();

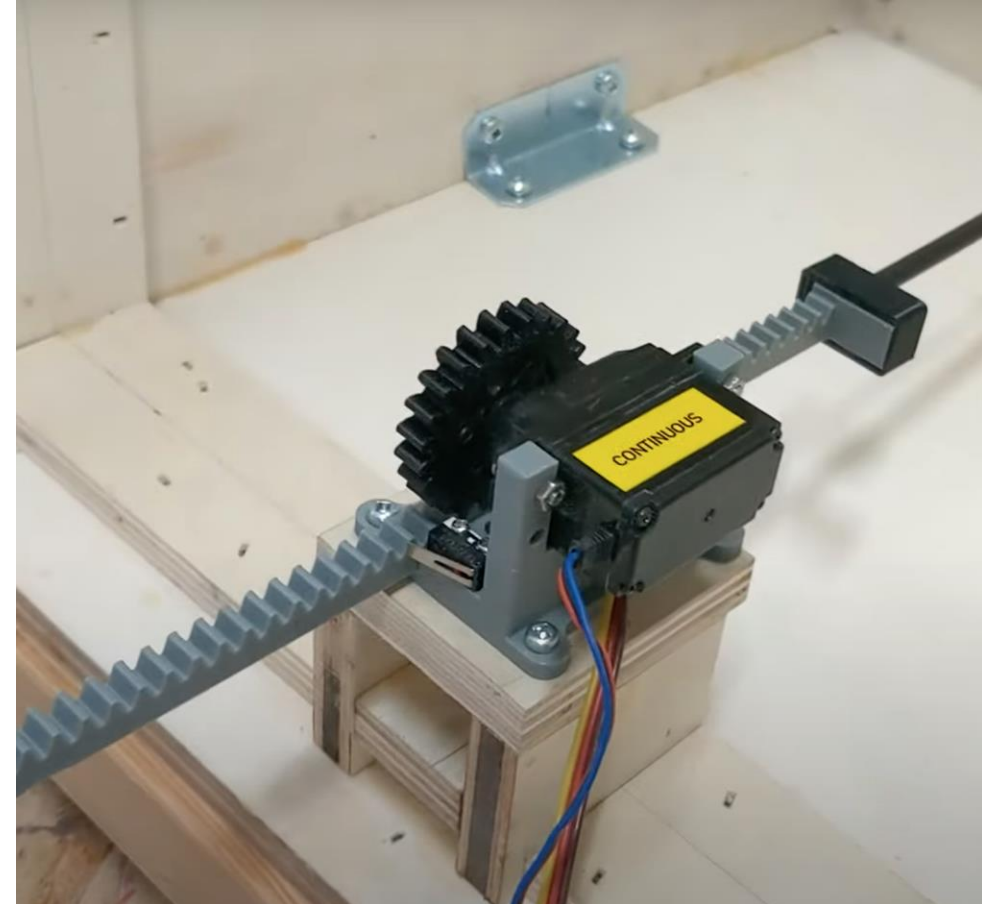
  // Set motor speed and direction
  if (Output > 0) {
    analogWrite(motorPWM, Output);
    digitalWrite(motorDirForward, HIGH);
    digitalWrite(motorDirReverse, LOW);
  } else {
    analogWrite(motorPWM, -Output);
    digitalWrite(motorDirForward, LOW);
    digitalWrite(motorDirReverse, HIGH);
  }
}
```

Controls / Simulations



Testing & Validation - Steering

- Inspect teeth for damage
- Test rotation of rack & pinion without motor
- Test rotation of rack & pinion with motor



Testing & Validation - Power

- Get multimeter battery readings for a regular run
- Compare readings for autonomous runs

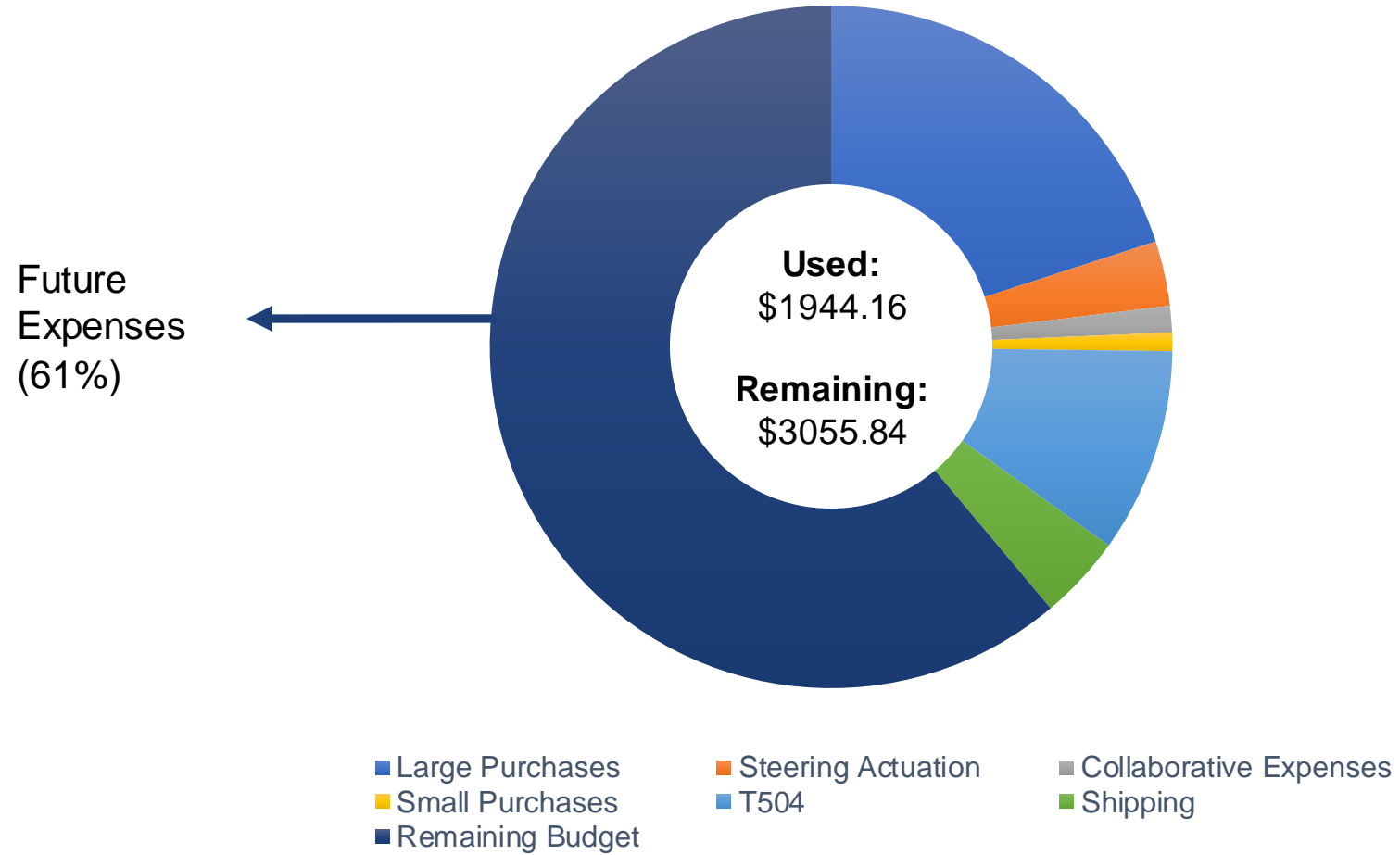


Testing & Validation - Velocity

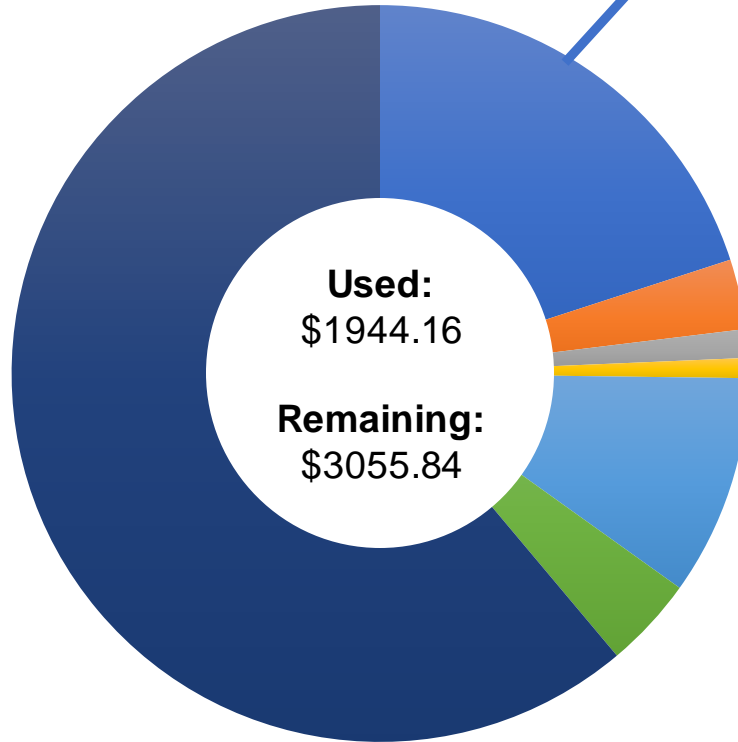
- Time trials



Budget



Budget

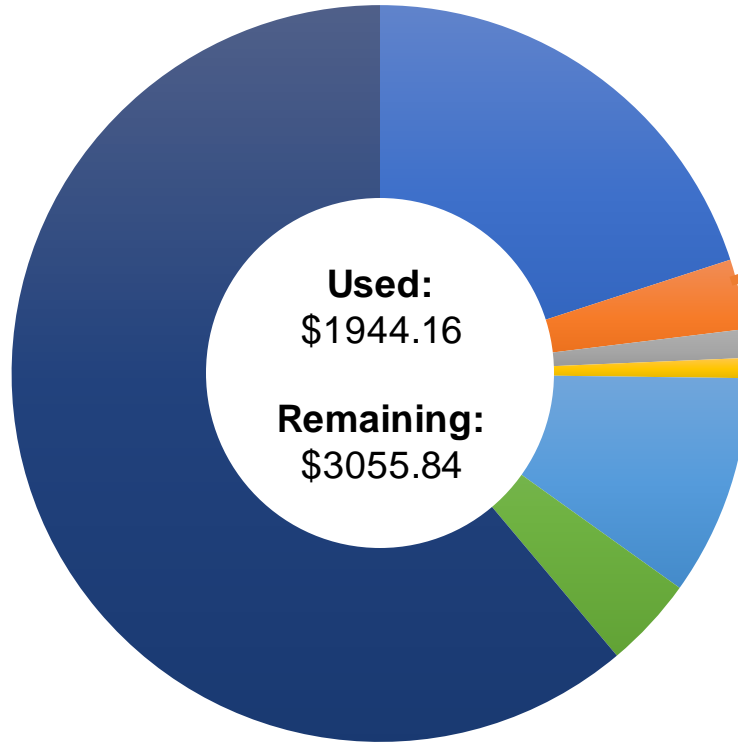
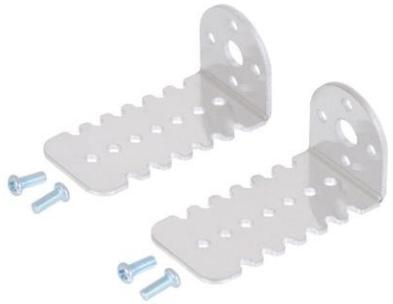


Tesla Model S Power wheel
(20%)

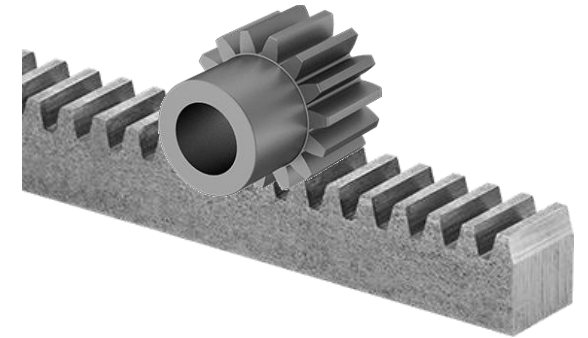


- Large Purchases
- Small Purchases
- Remaining Budget
- Steering Actuation
- T504
- Collaborative Expenses
- Shipping

Budget

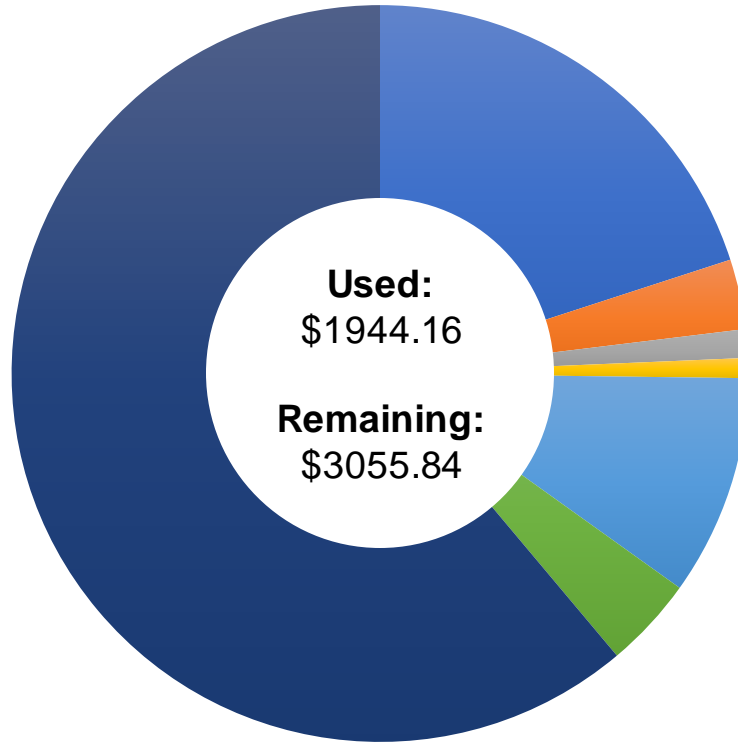
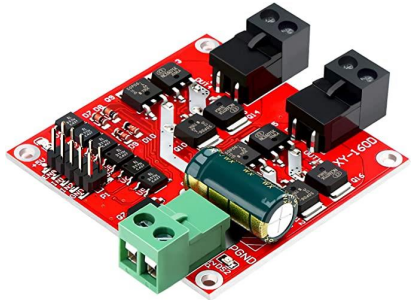


Motor, bracket, rack & pinion (3%)



- Large Purchases
- Small Purchases
- Remaining Budget
- Steering Actuation
- T504
- Collaborative Expenses
- Shipping

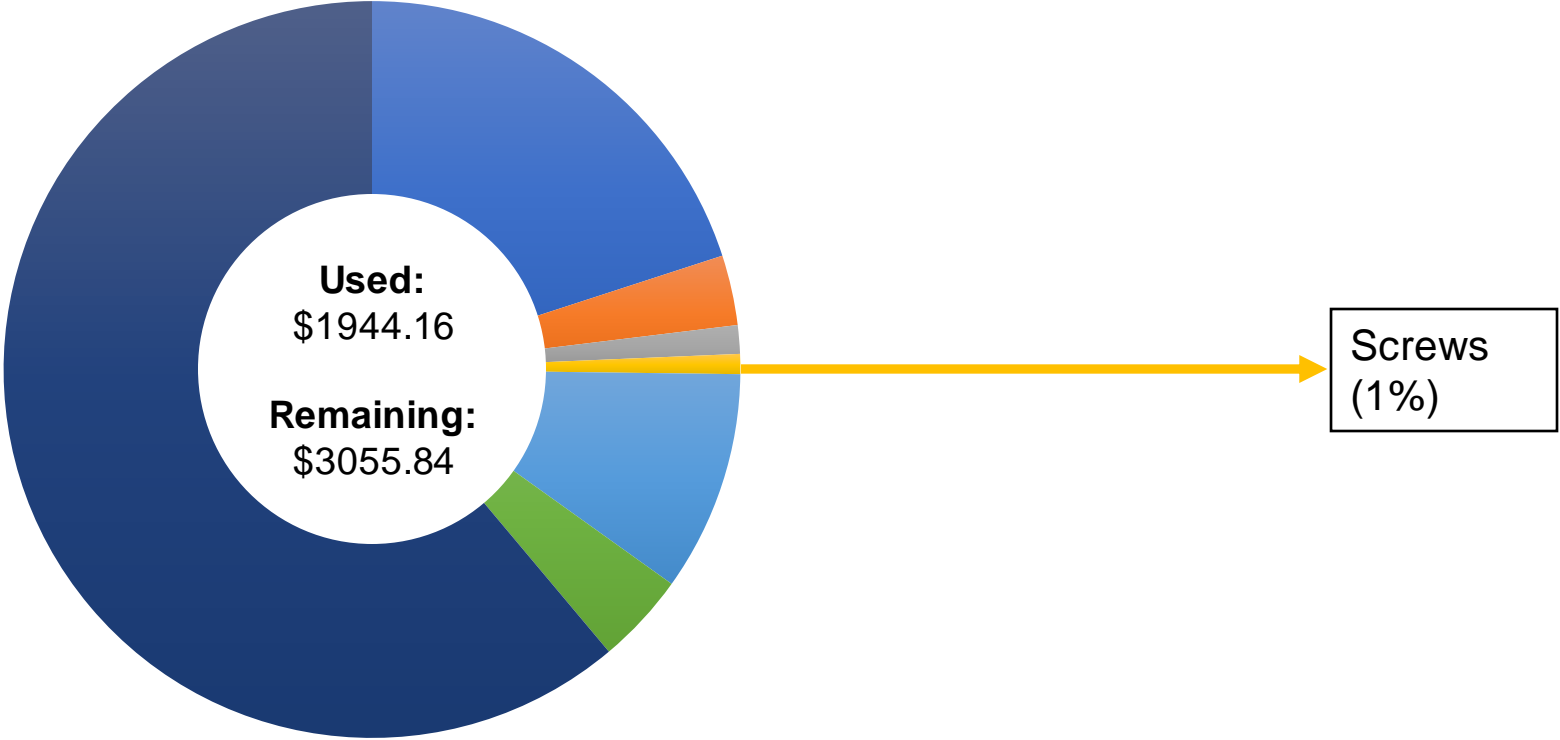
Budget



Motor driver and emergency switch (1%)

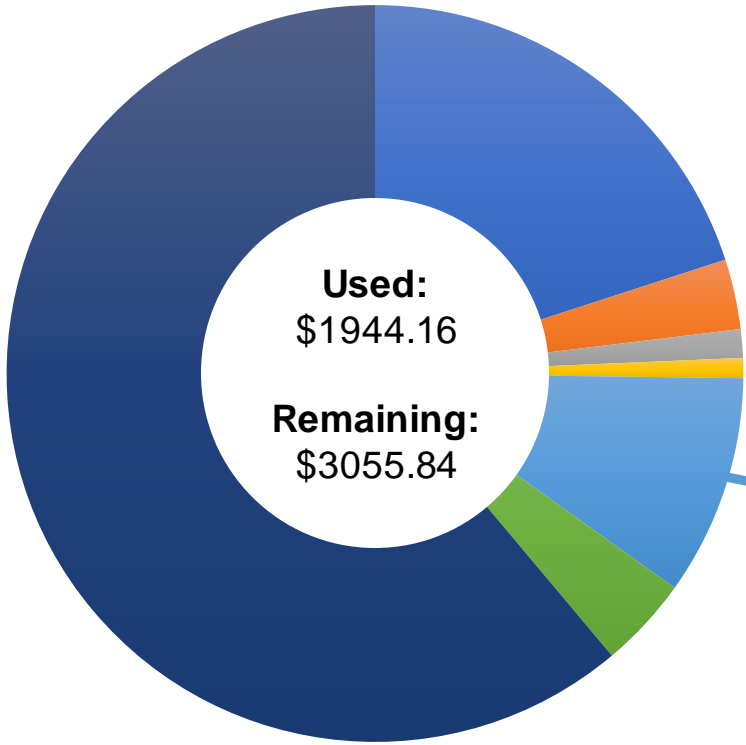
- Large Purchases
- Small Purchases
- Remaining Budget
- Steering Actuation
- T504
- Collaborative Expenses
- Shipping

Budget



- Large Purchases
- Small Purchases
- Remaining Budget
- Steering Actuation
- T504
- Collaborative Expenses
- Shipping

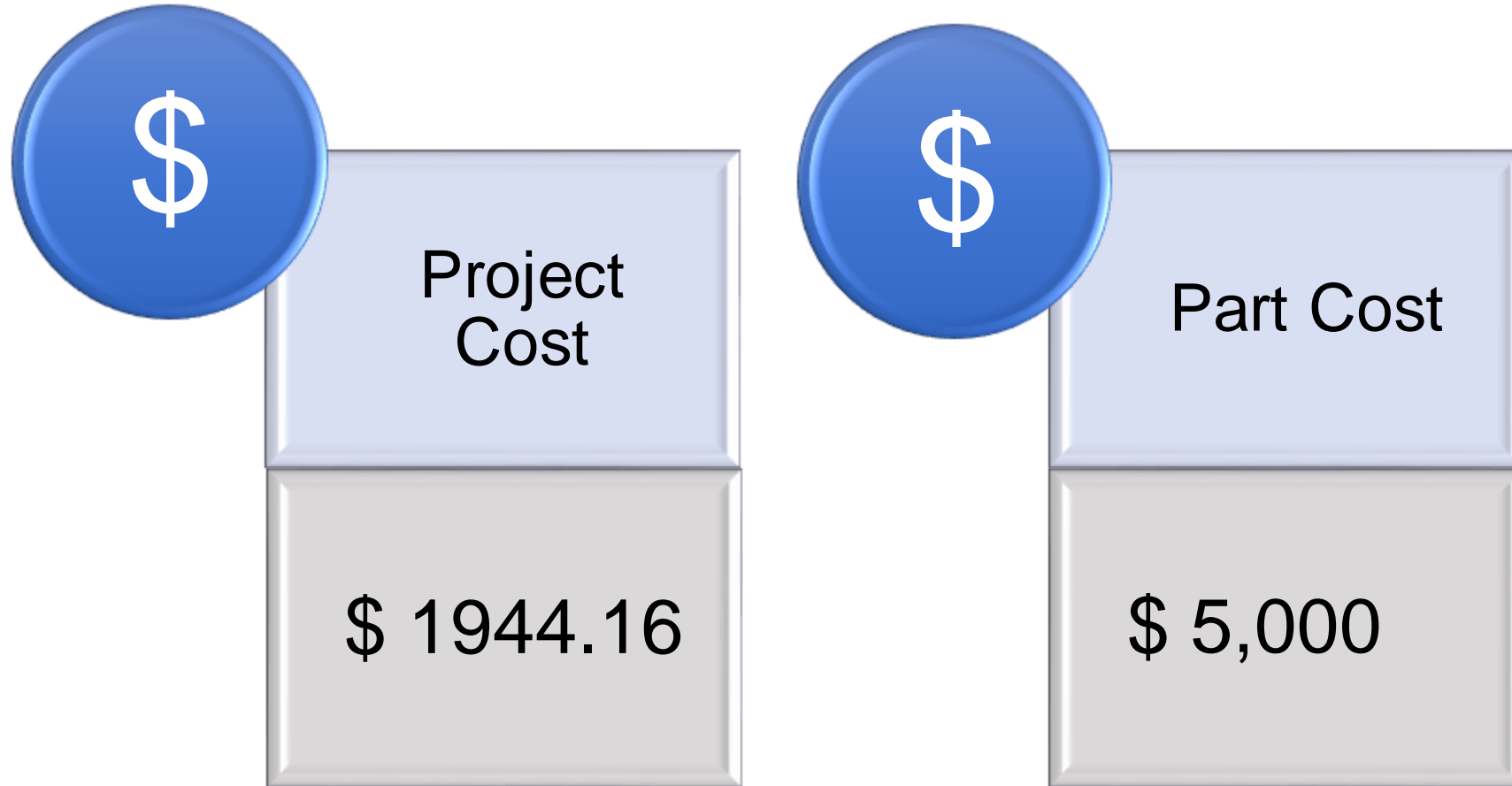
Budget



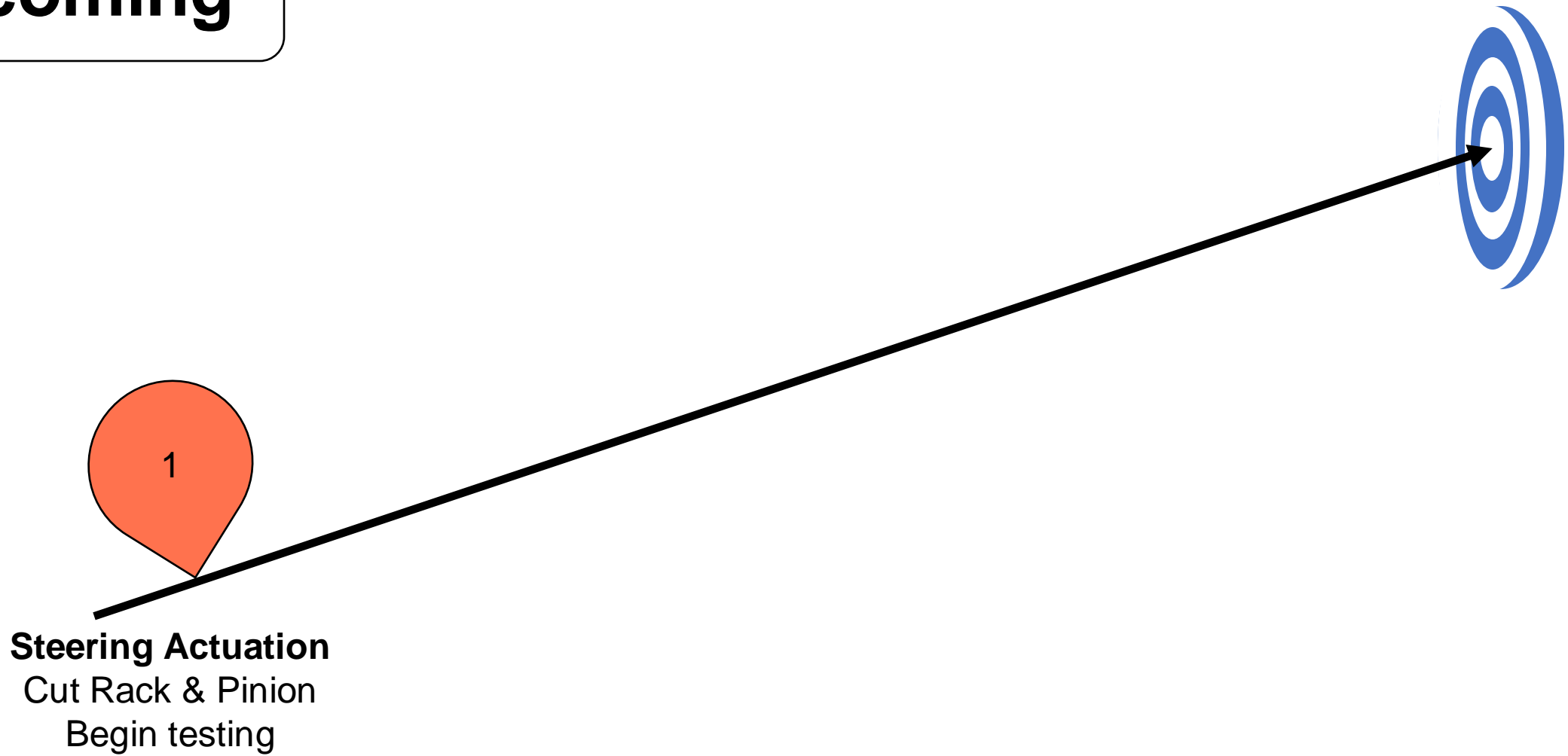
Camera, led, etc.
(9%)

- Large Purchases
- Steering Actuation
- Collaborative Expenses
- Small Purchases
- T504
- Shipping
- Remaining Budget

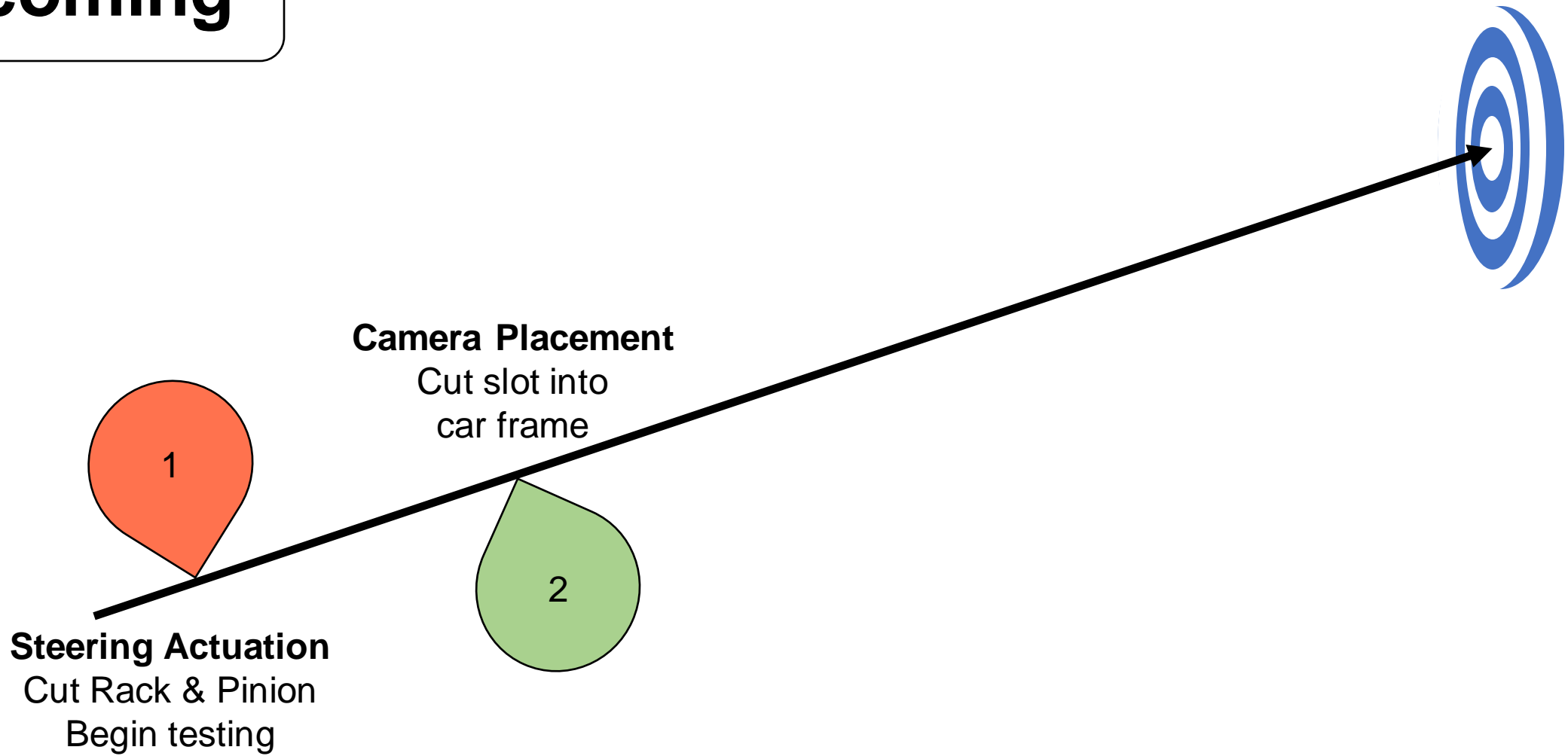
Budget



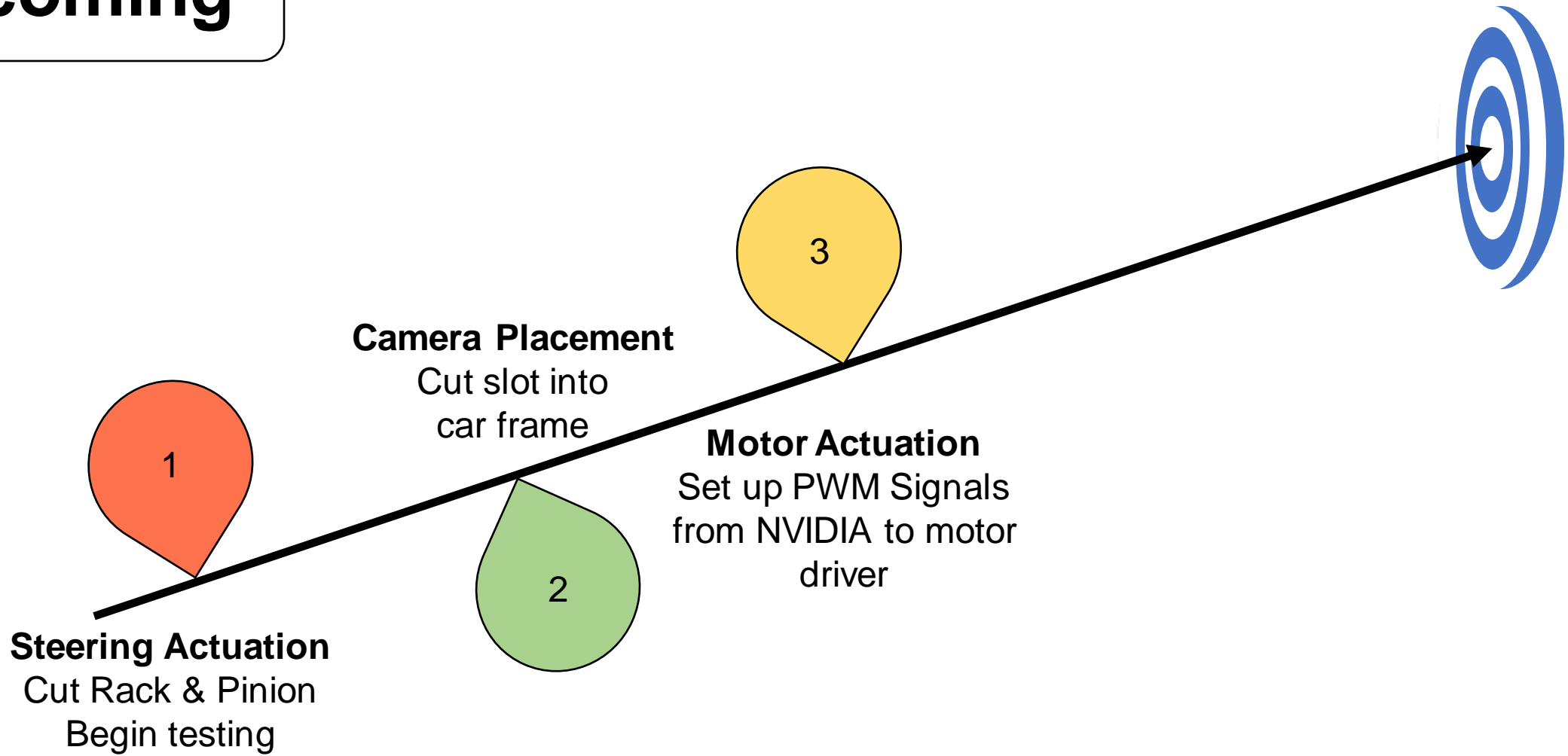
Upcoming



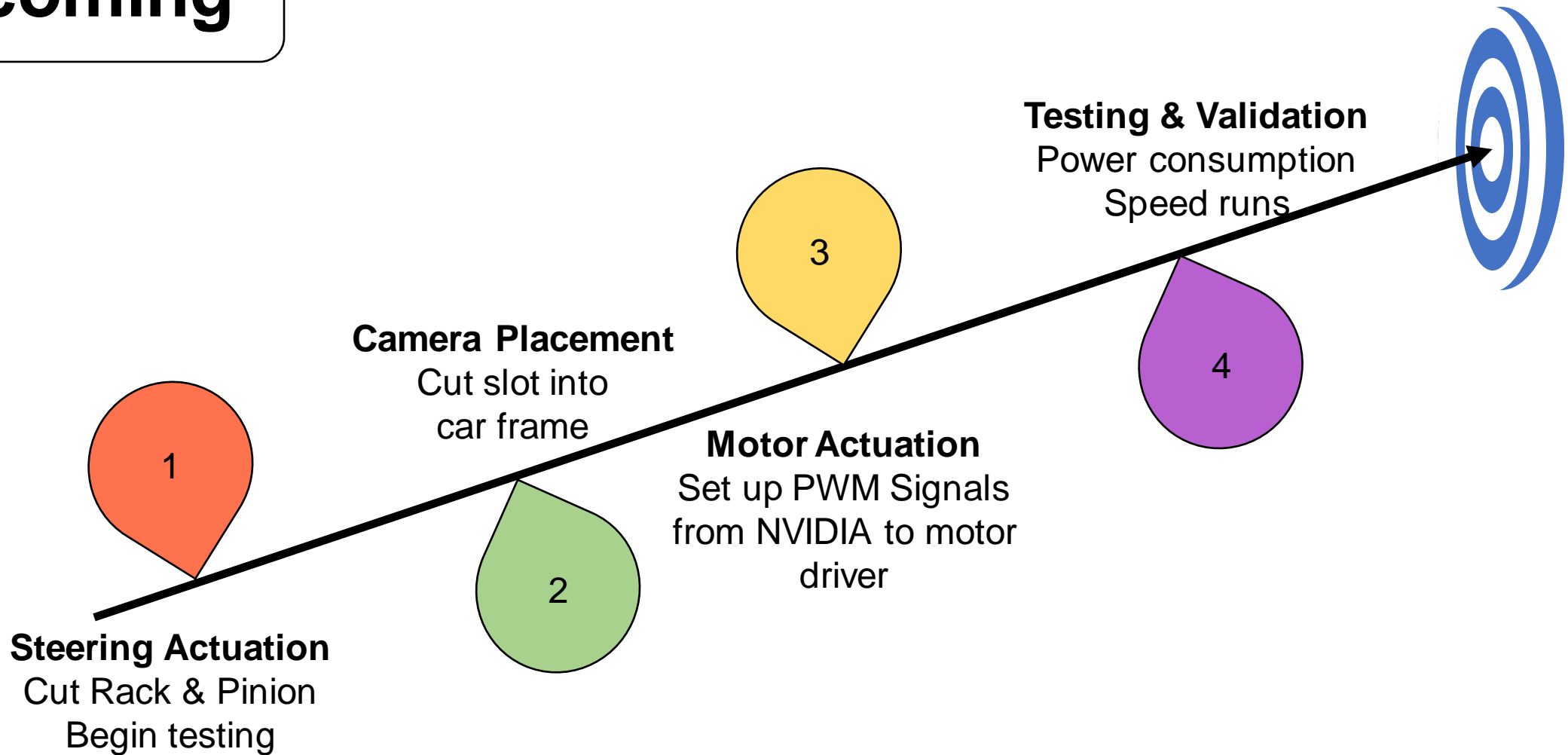
Upcoming



Upcoming



Upcoming



TEAM 503



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