DATA EXTRACTION

MILESTONE 2

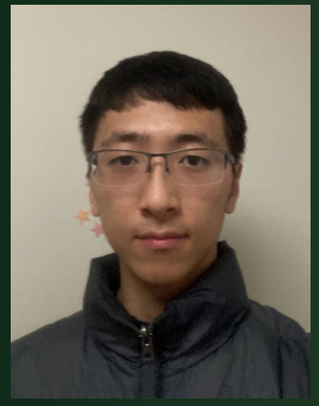
"OSCAR THE GROUCH"

Vihaan Le
Mission

Steven Vilcheck
Mission, Chassis

Ella Bierly
Locomotion

Jacquelyn Eng
Locomotion



Phillip Chen
Electrical

Ariana Butterworth
Electrical

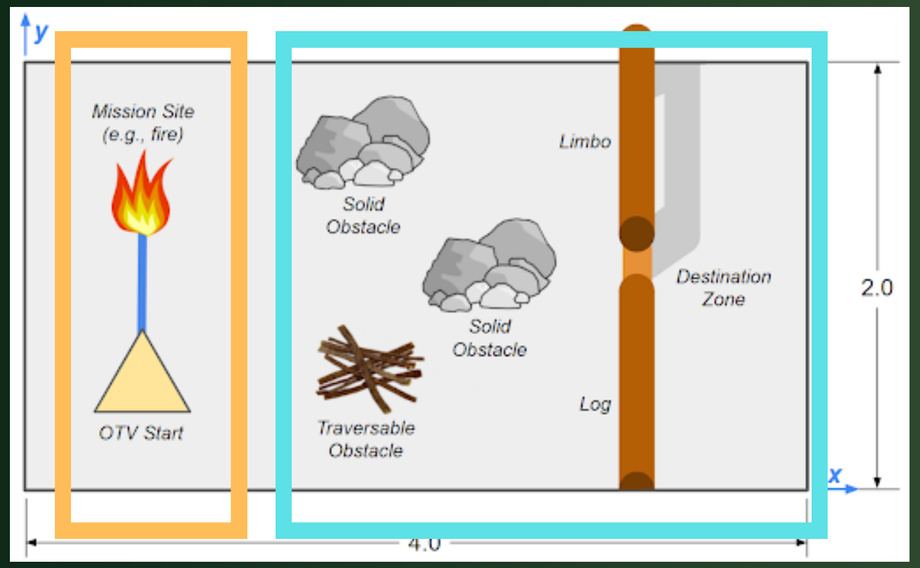
Thomas Kimberlin
Arduino

Ryan Tran
Arduino

OSCAR'S OBJECTIVES

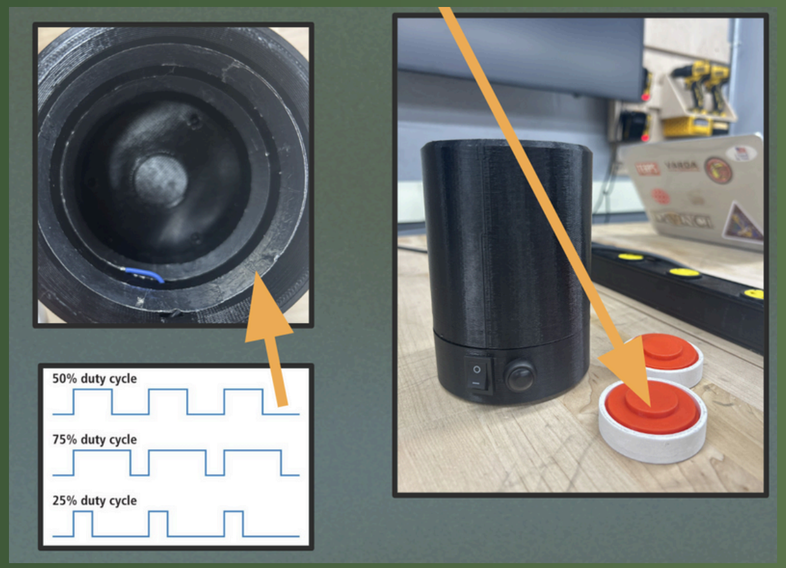
NAVIGATE COURSE

- Use array of sensors to determine position of OTV and obstacles to navigate through Payload, then Arena



DATA EXTRACTION

- Claw picks up silo
- Claw empties contents onto silo interface plate



CONSTRAINTS

LOCOMOTIVE

- Motors must handle a minimum of 3kg weight and 0.7 coefficient of rolling resistance
- Coefficient of friction of the treads vs. the arena floor

CHASSIS

- Overall OTV under $320 and 3kg
- Must have 115mm x 115mm space for Aruco tracker on top

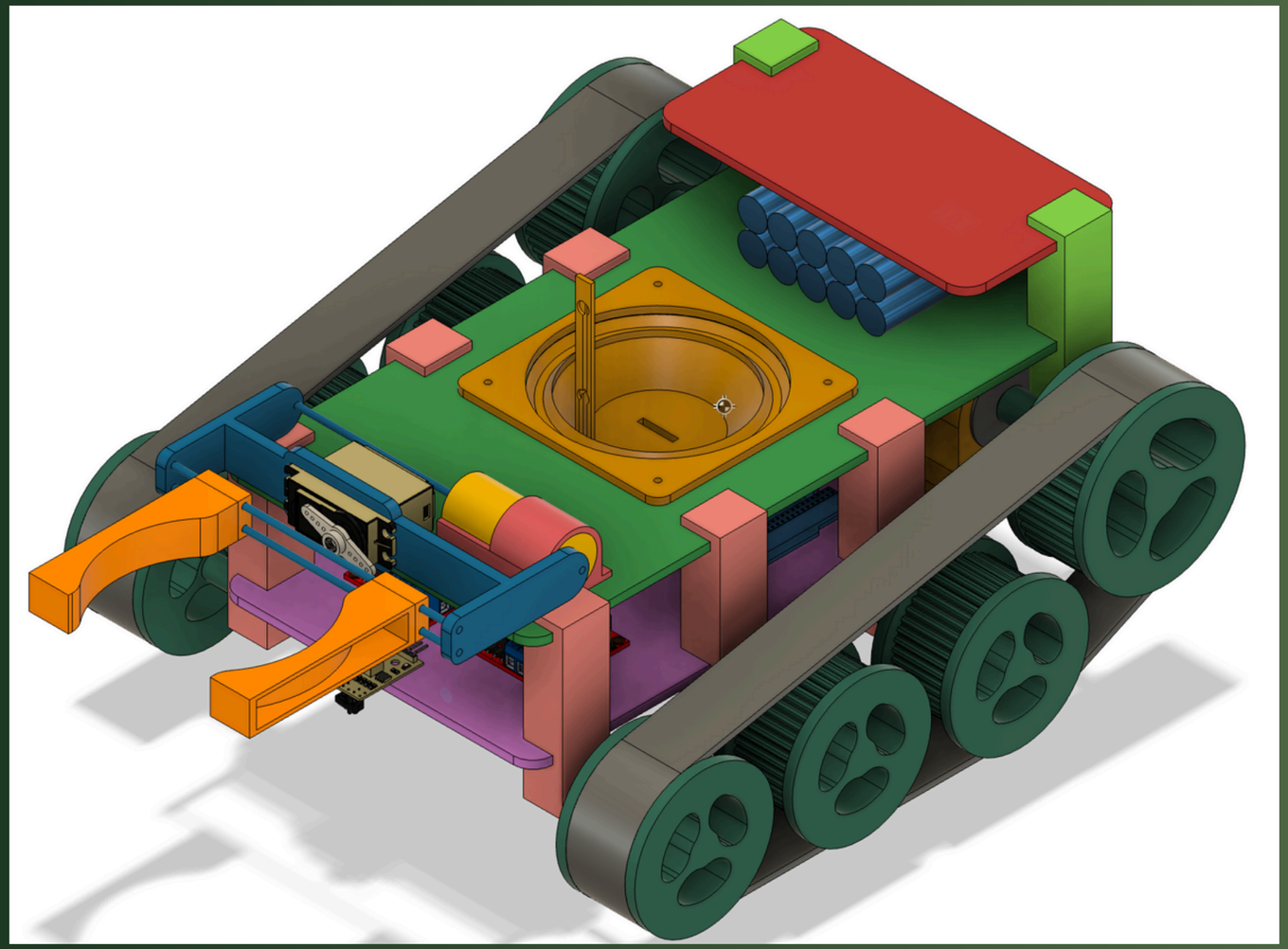
ELECTRICAL

- Must consider power, current draw, and voltage of all electrical components

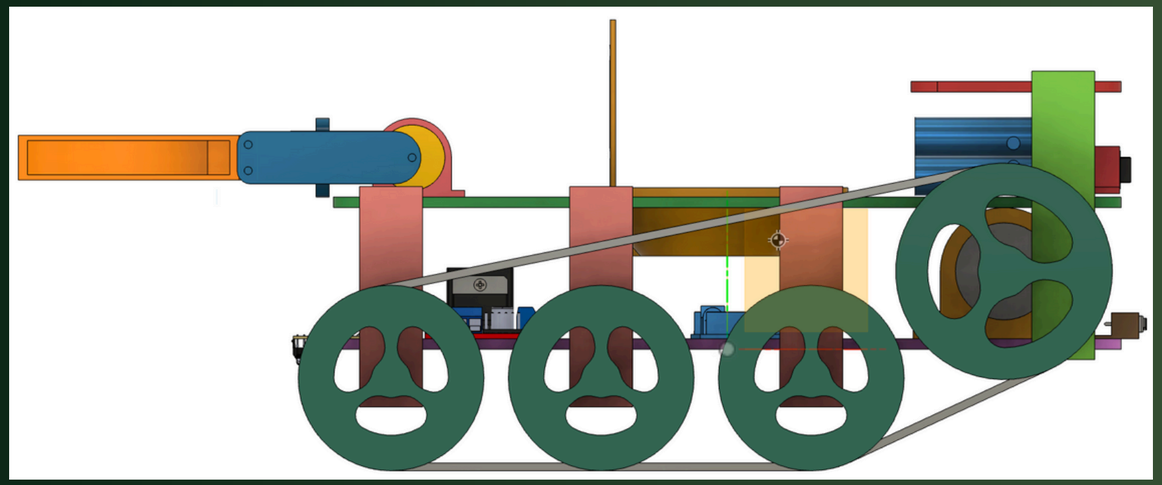
ARDUINO

- Functions of sensors used to navigate and complete mission objectives

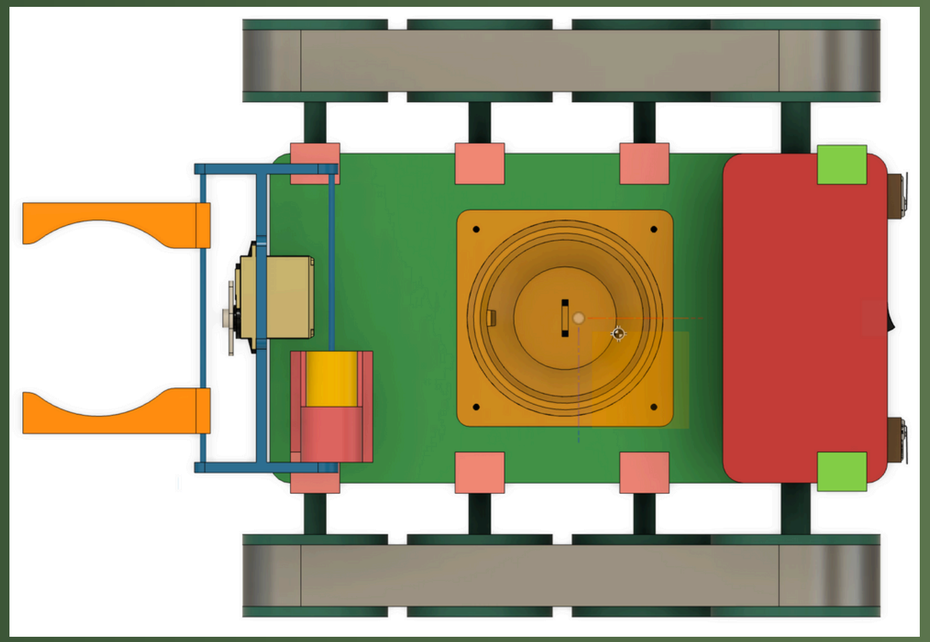
OTV CAD



OTV CAD



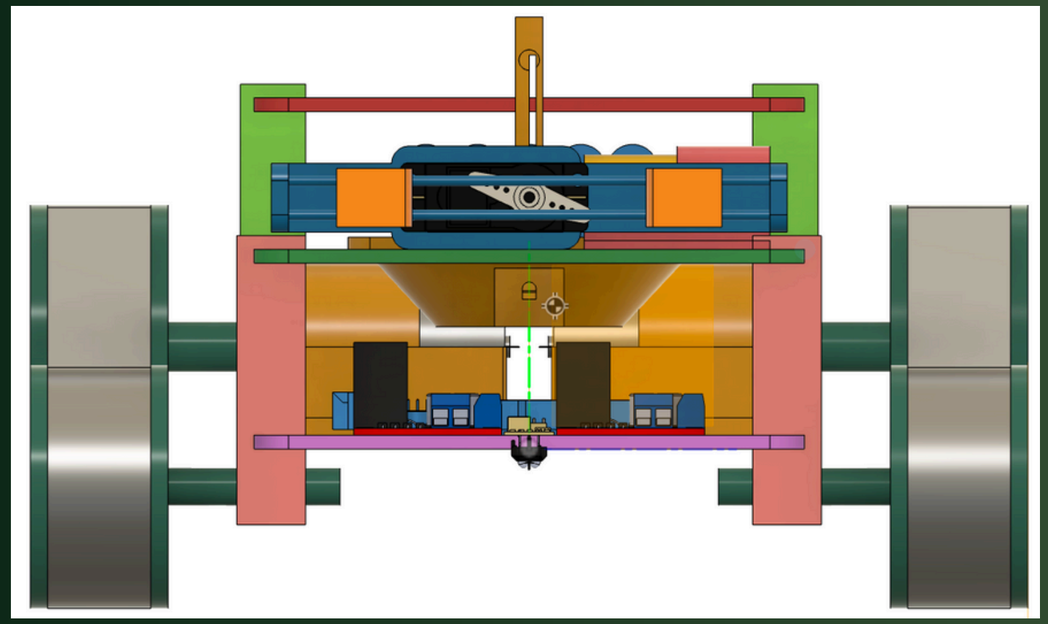
Front view



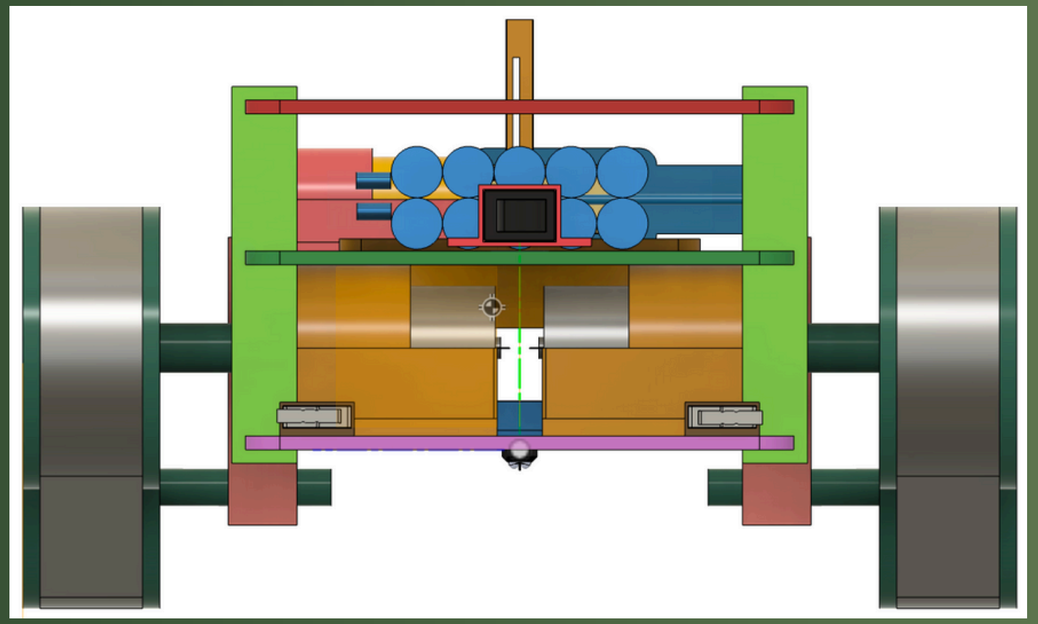
Top View

Center of Mass [mm]:
(19.172, 41.293, 7.794)

OTV CAD



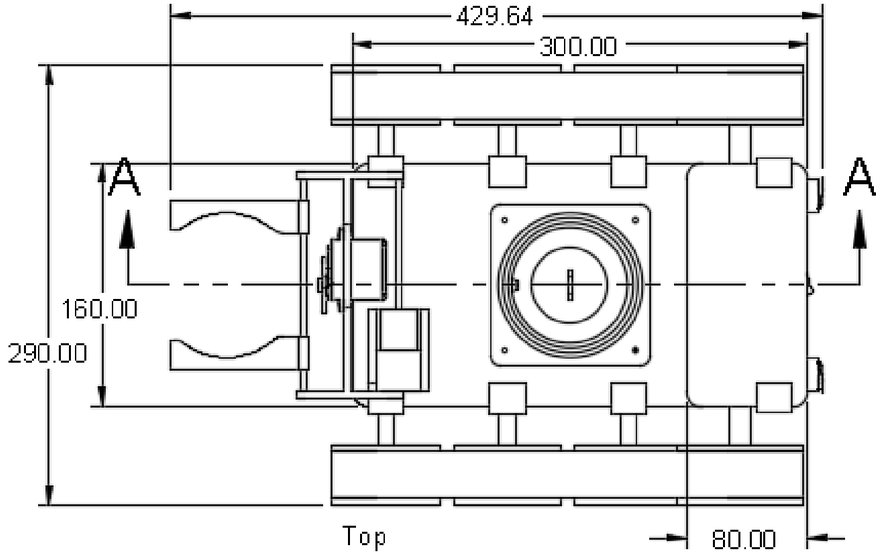
Front view

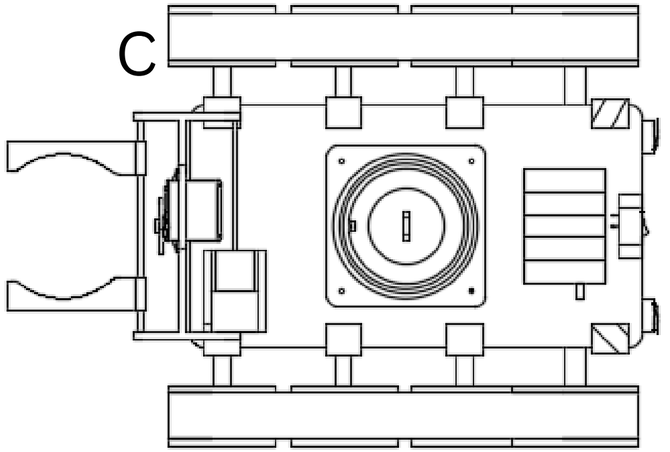


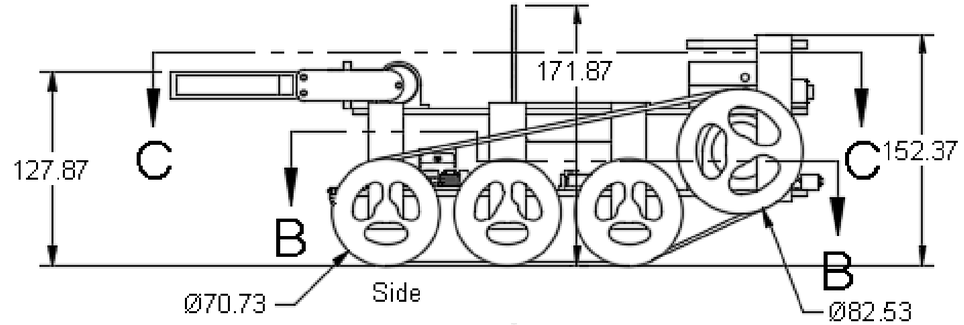
Back View

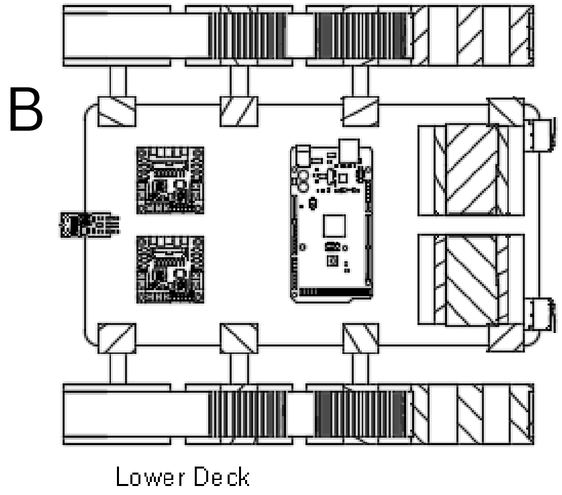
Center of Mass [mm]:
(19.172, 41.293, 7.794)

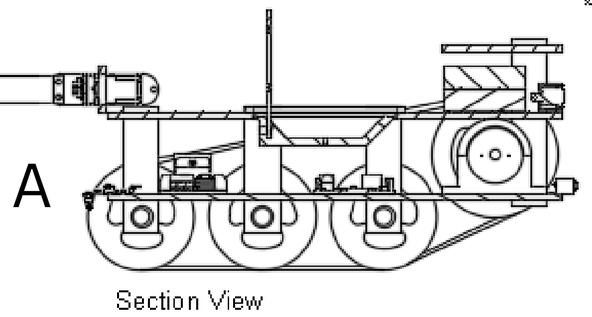
OTV CAD





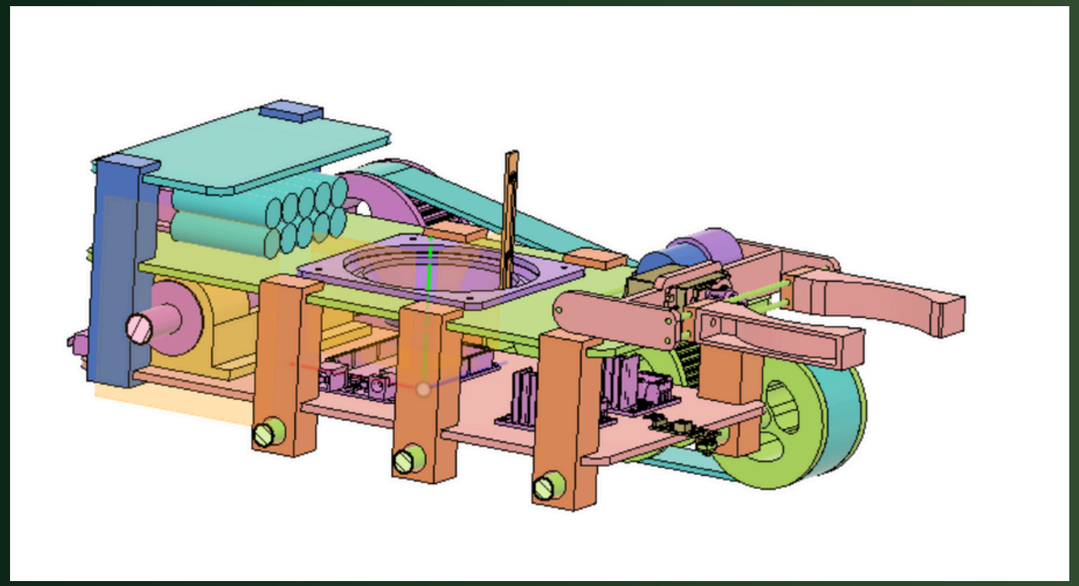






All Dimensions in mm

CHASSIS DEVELOPMENT



ARRANGEMENTS

- Electronics housed on bottom deck
- Missions systems mounted on middle deck

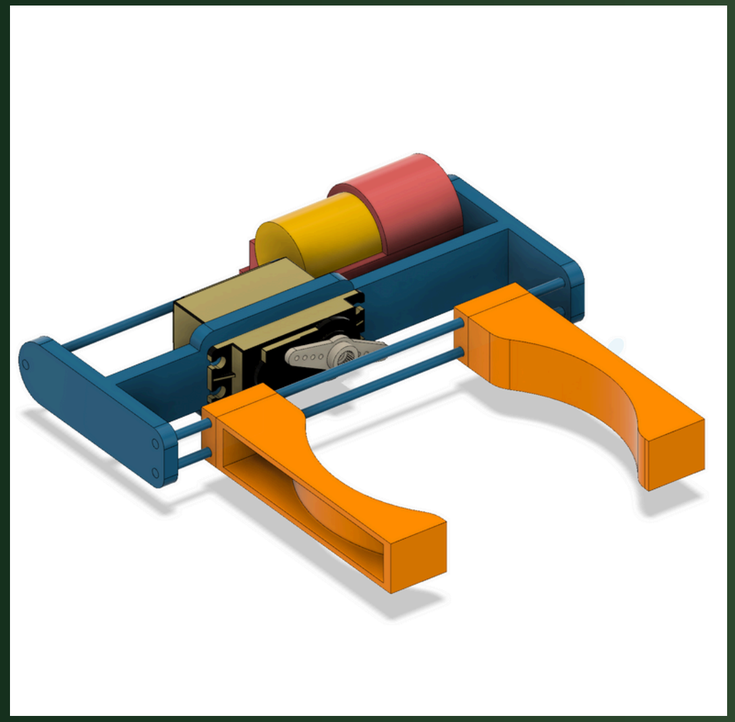
MATERIALS

- 3 layers of cut PLA
- 3D-printed spacers

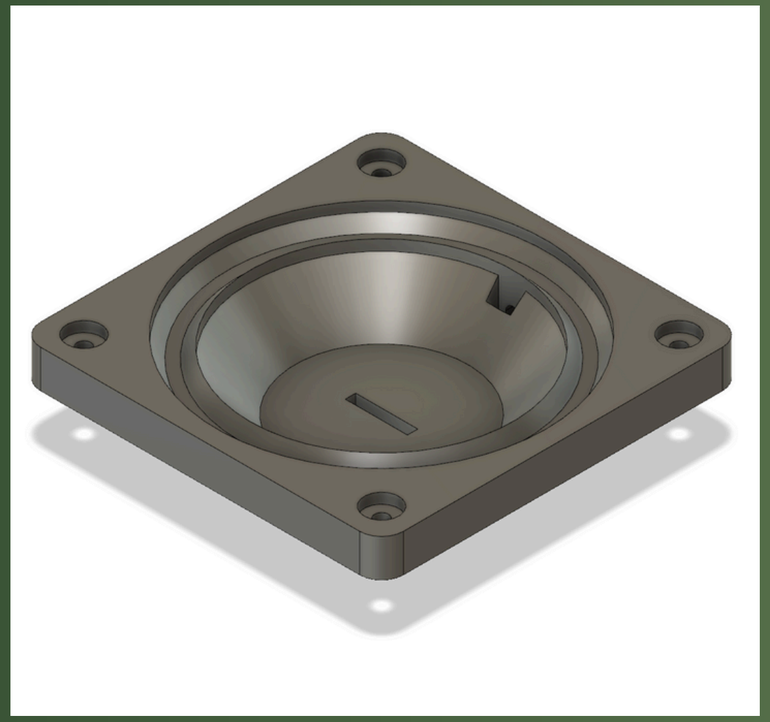
CAVEATS

- Final dimensions dependent on subteams
  - EX: spacer height adjusted based on height of claw

MISSION SYSTEMS

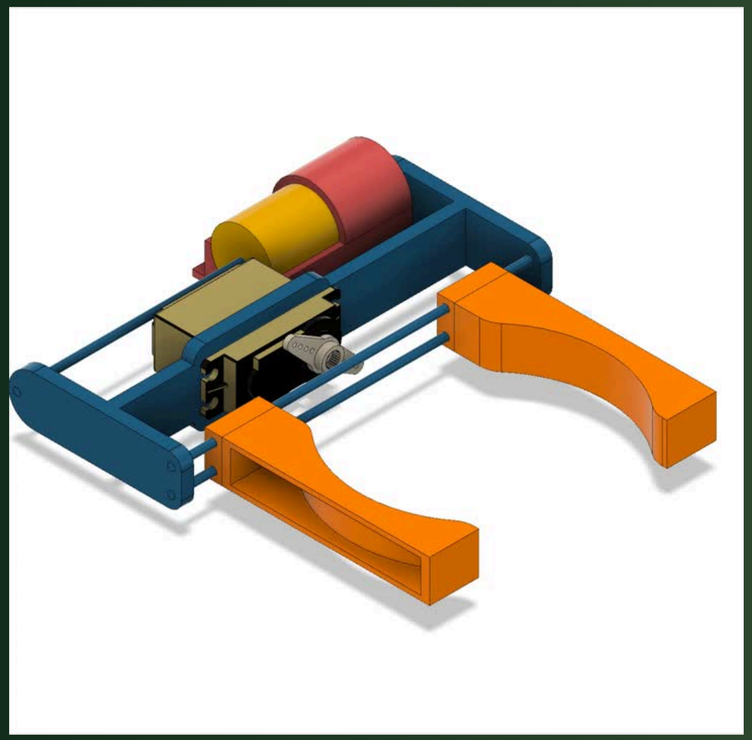


Claw

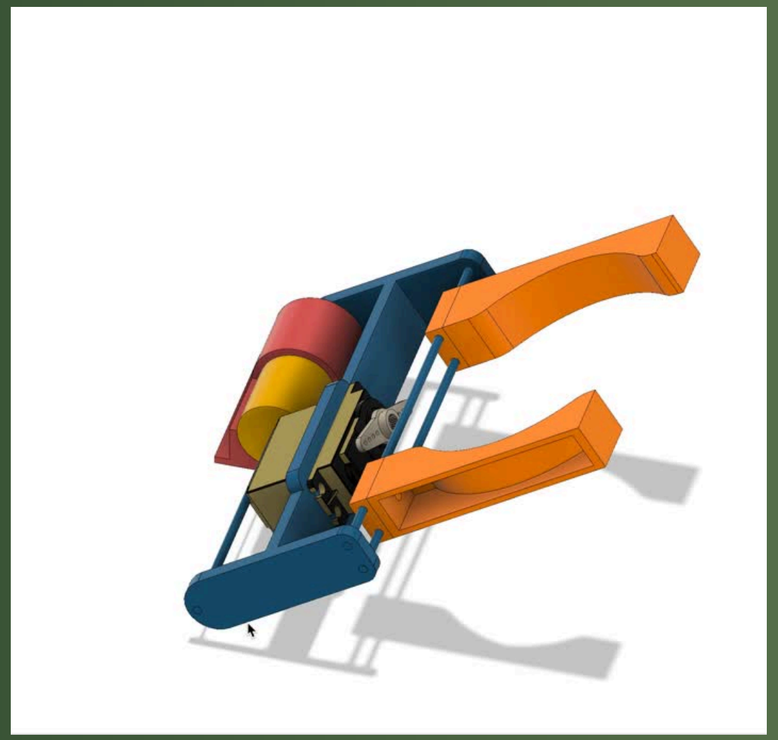


Silo Interface Plate

MISSION SYSTEMS

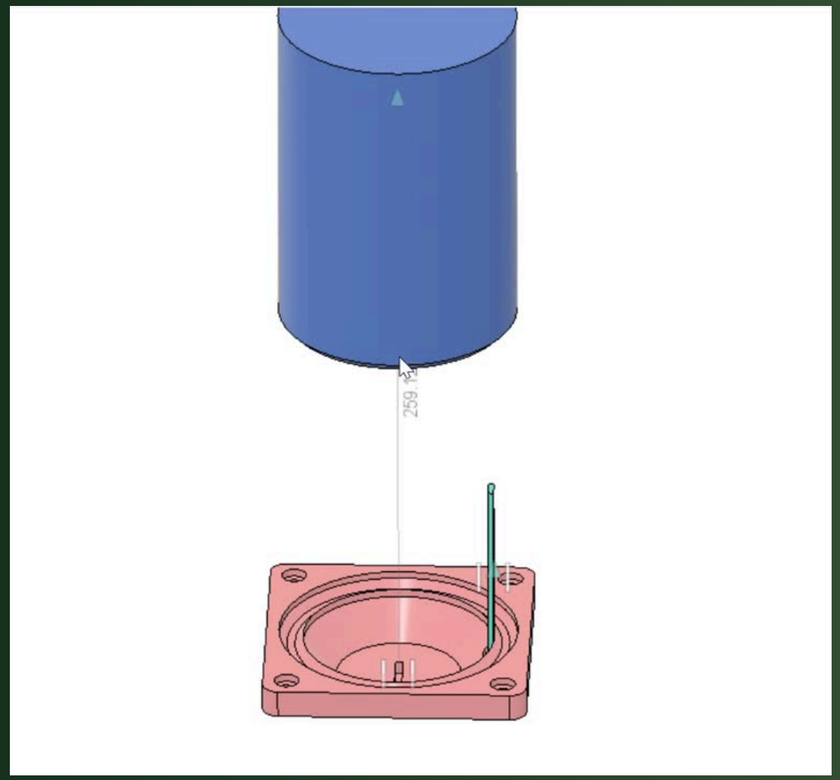


Grabbing Mechanism

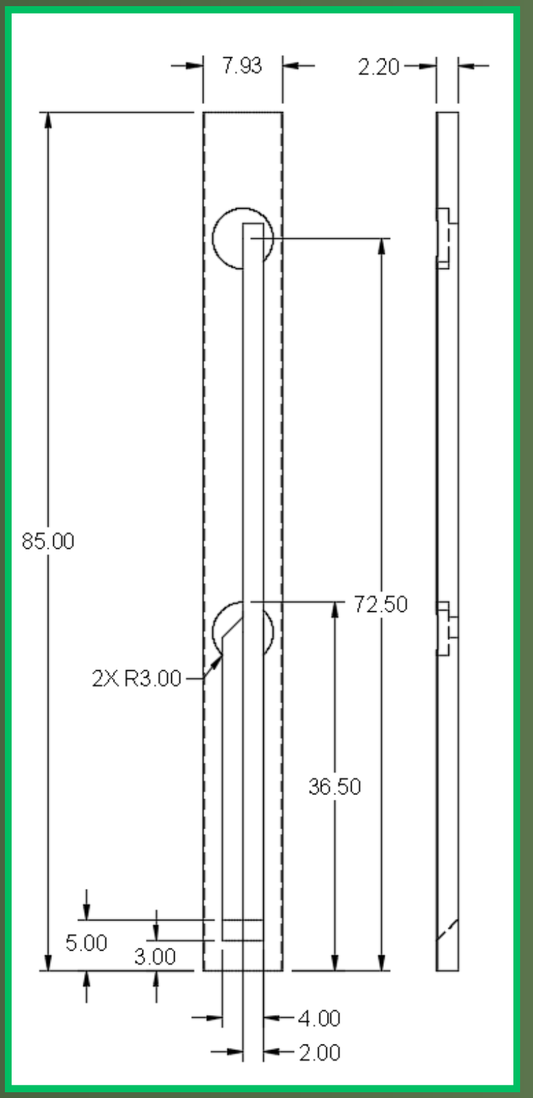


Flipping Mechanism

MISSION SYSTEMS

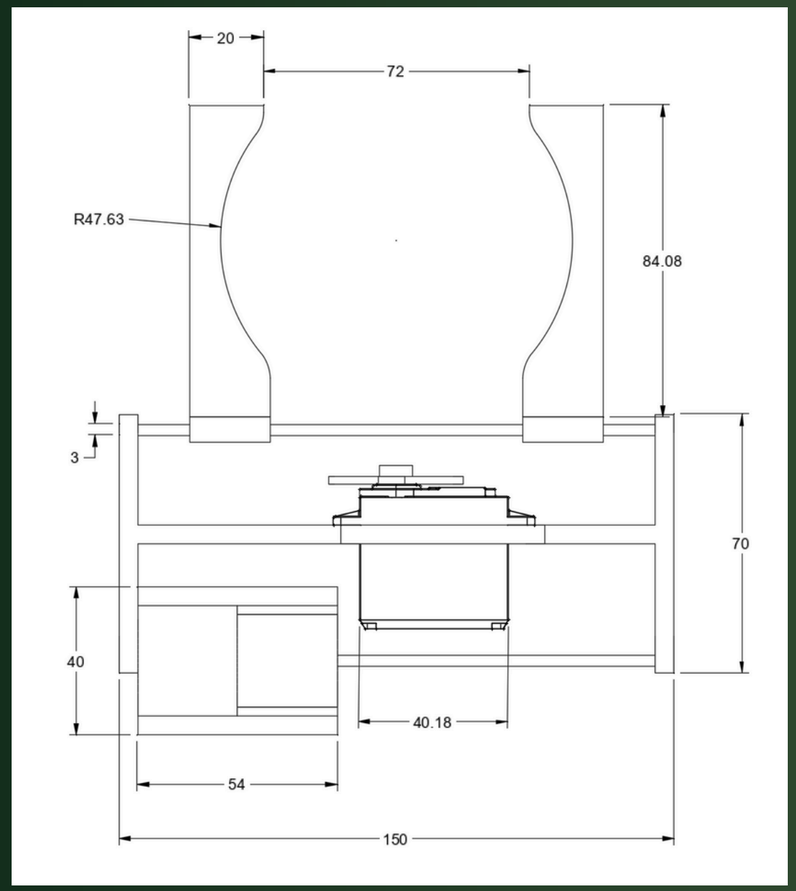


Silo and Interface Plate

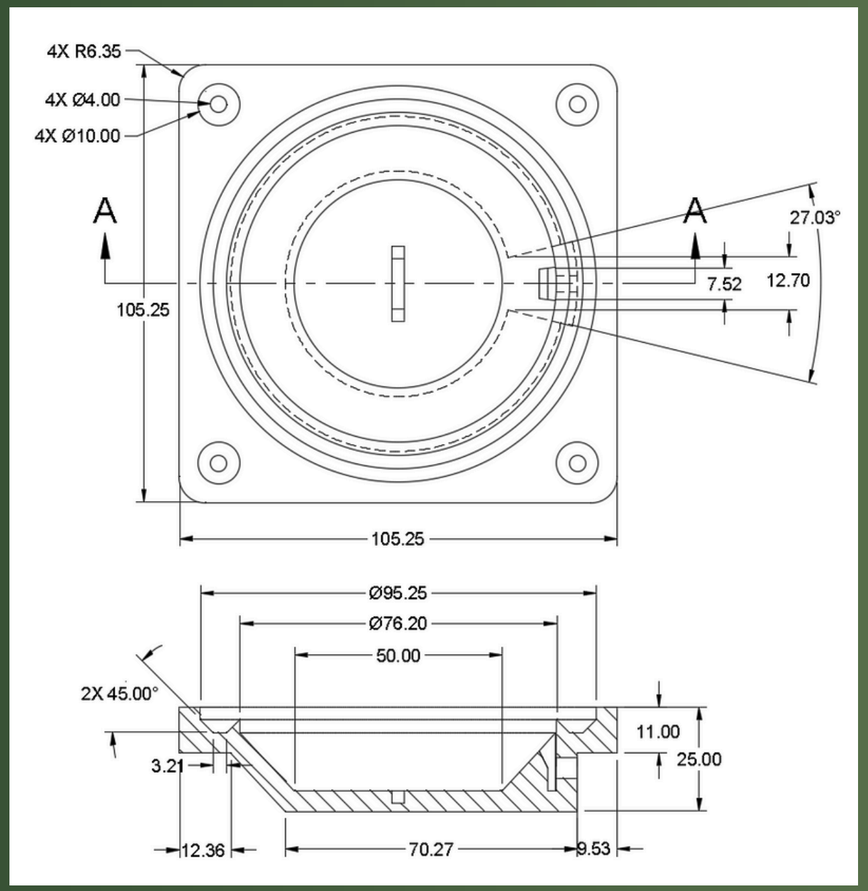


Antenna

MISSION SYSTEMS DIMENSIONS

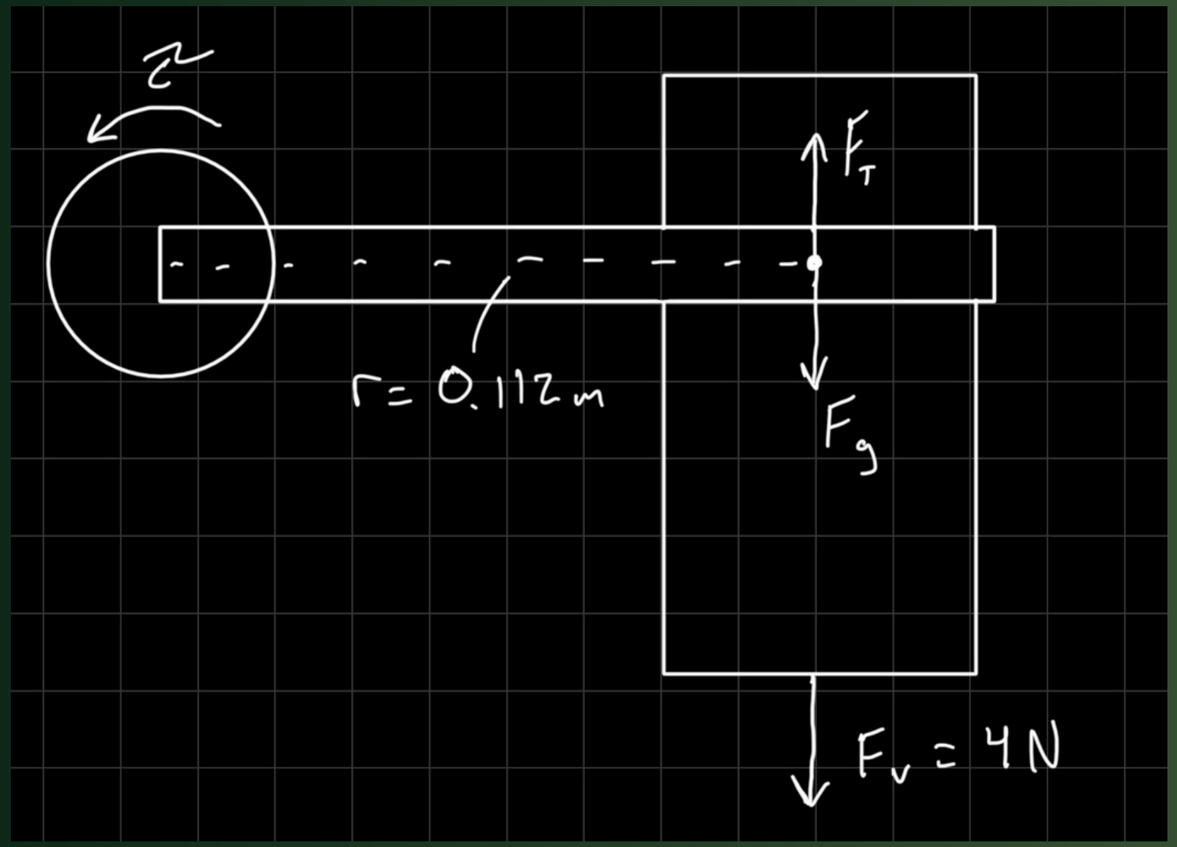


Claw



Silo Interface Plate

MISSION CALCULATIONS



FBD

r = length of arm = 0.112m
F_v = pulling force of velcro = 4N
m = mass of pylon = 1 kg
F_g = force of gravity

$F_g = (1)(9.8) = 9.8N$

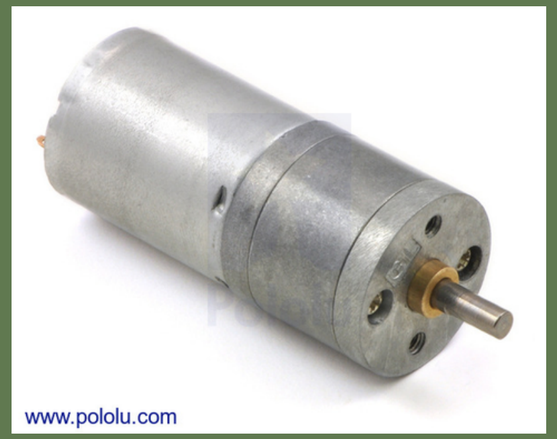
$\tau = (r)(F_v + F_g)$
$\tau = (0.112m)(4+9.8)$
$\tau = 1.54$ Nm = 15.6 kg-cm

Torque Calculation

MOTOR SELECTION

POLOLU MOTOR

The motor ensures a reasonable buffer between the expected and failure values

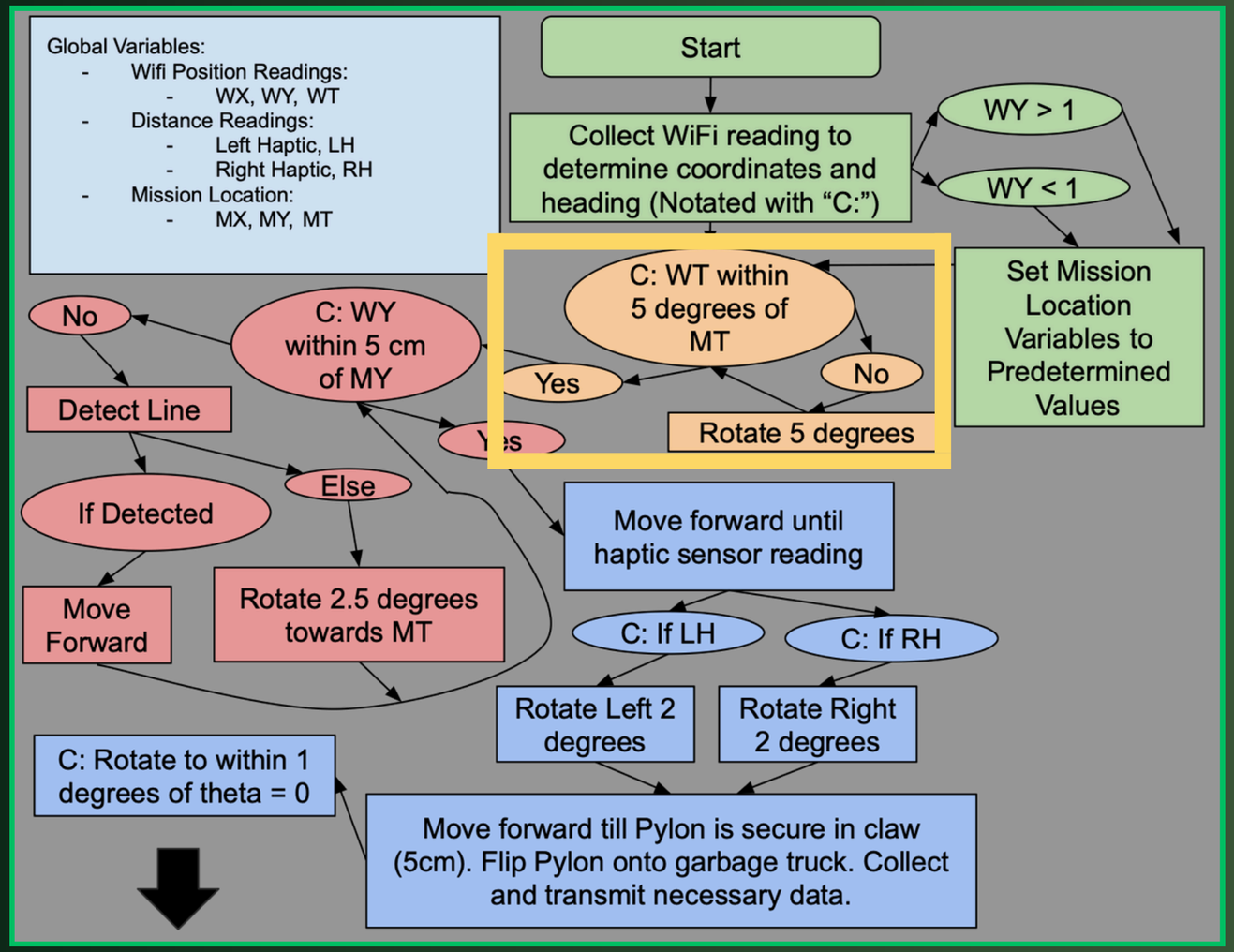


29.00>15.60 [kg*cm]

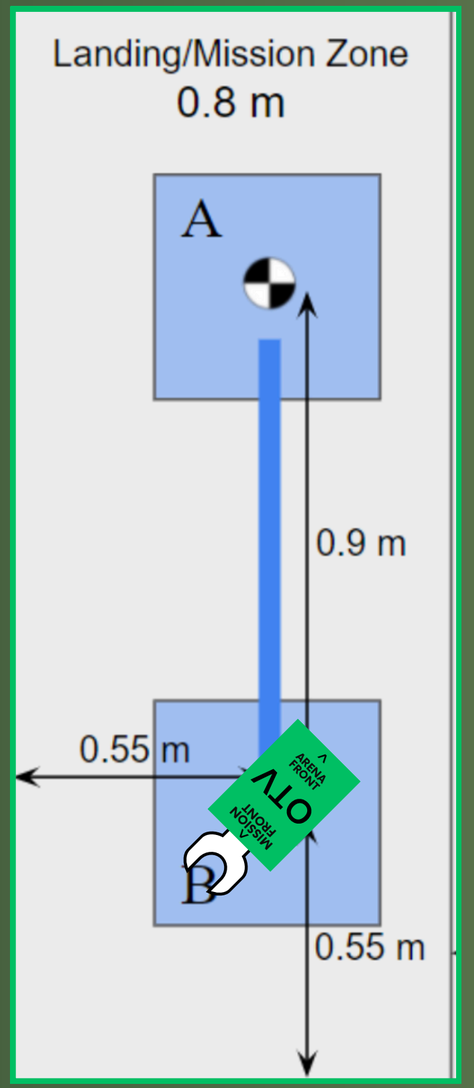
SPECIFICATIONS:

Rated Voltage [V]	12.00
No-Load/Stall Current [A]	0.25/5
No-Load Speed [rpm]	100
Stall Torque [kg-cm]	29.00

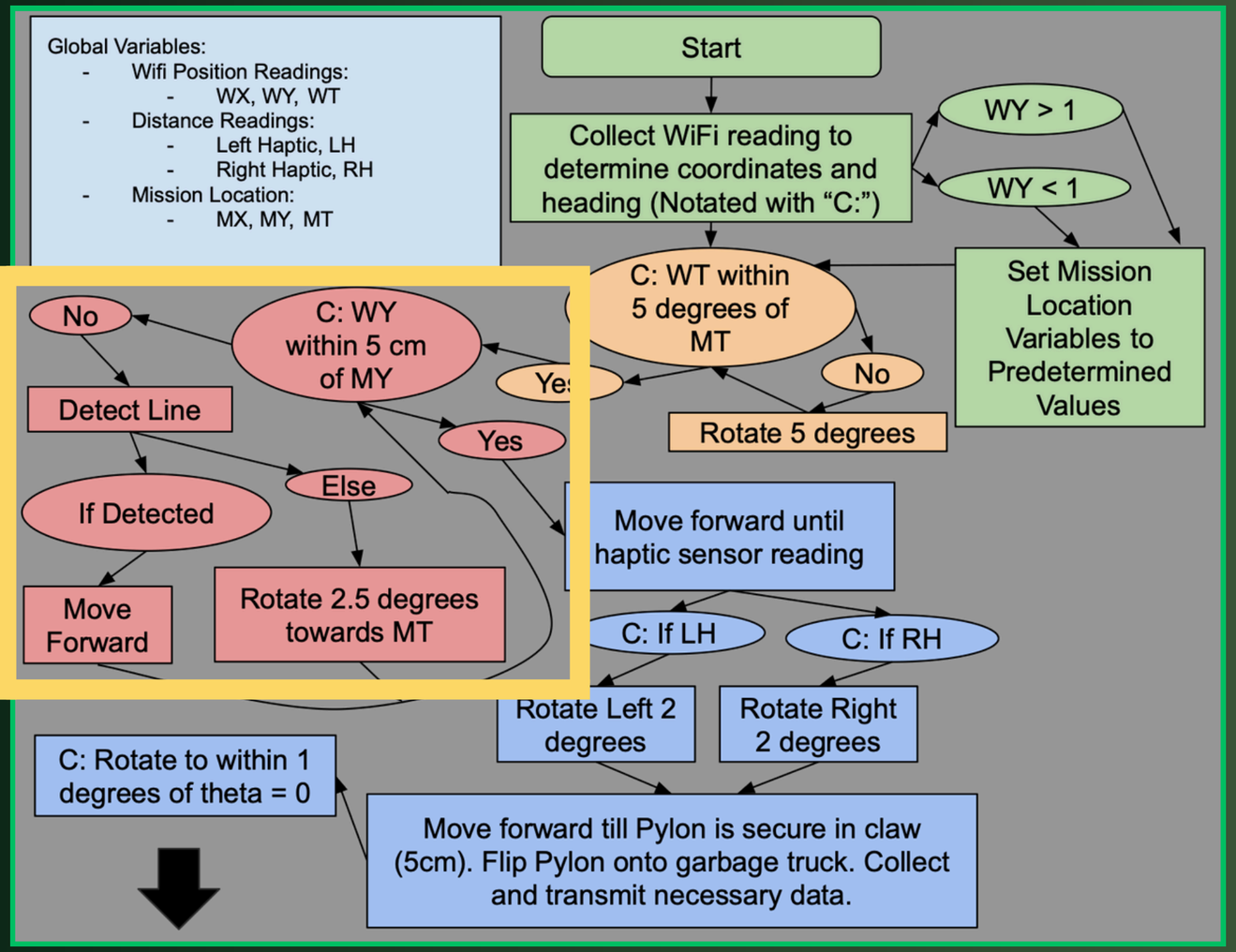
MISSION NAVIGATION FLOW CHART



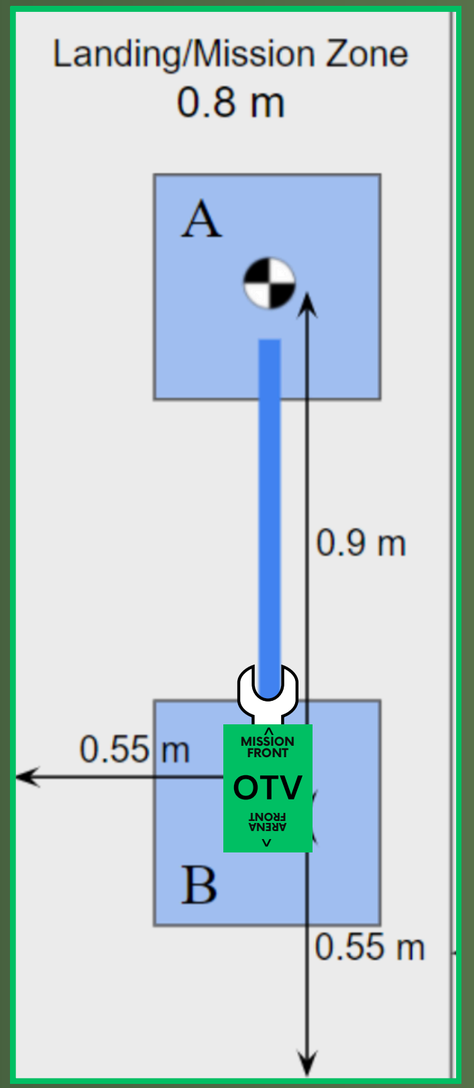
Coordinate:
(.55, .55)
Angle:
Theta = 135



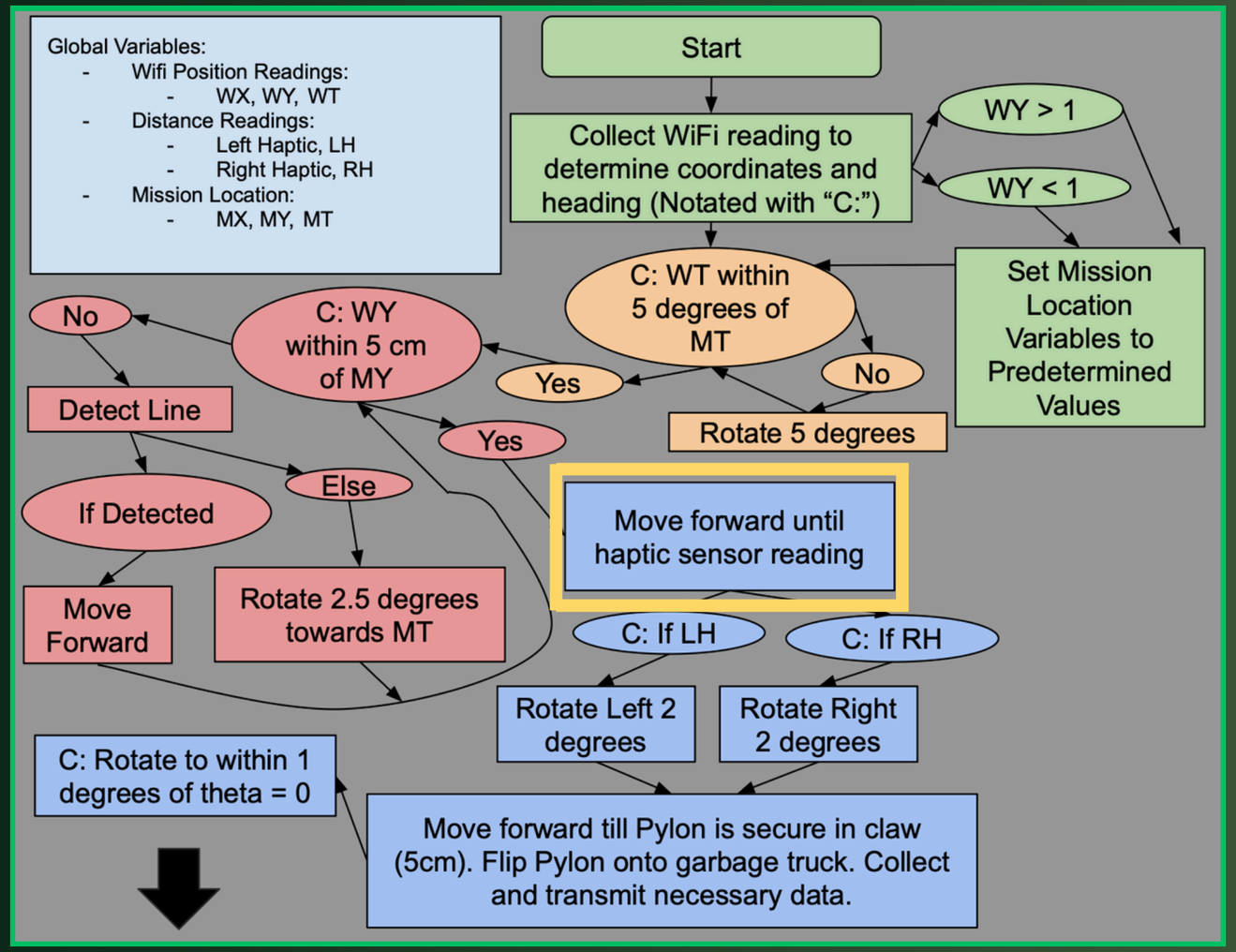
MISSION NAVIGATION FLOW CHART



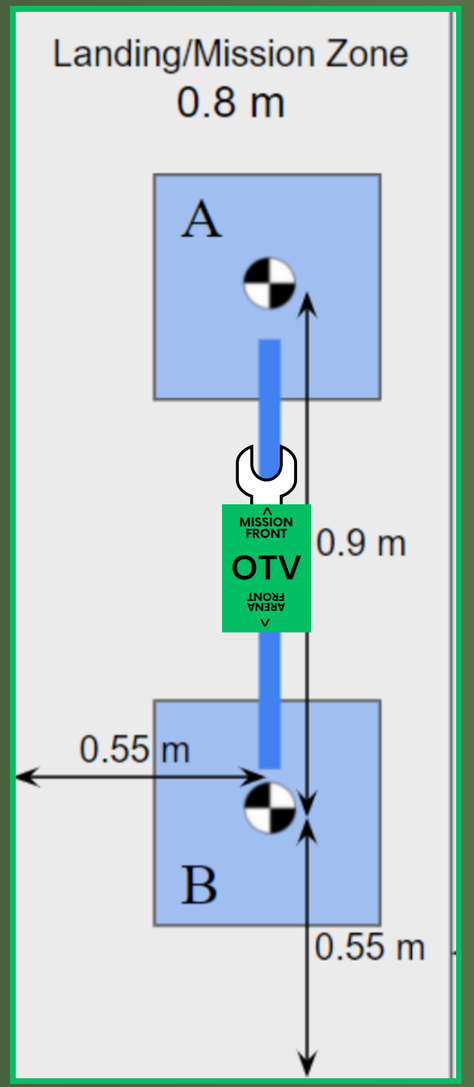
Coordinate:
(.55, .55)
Angle:
Theta = 0



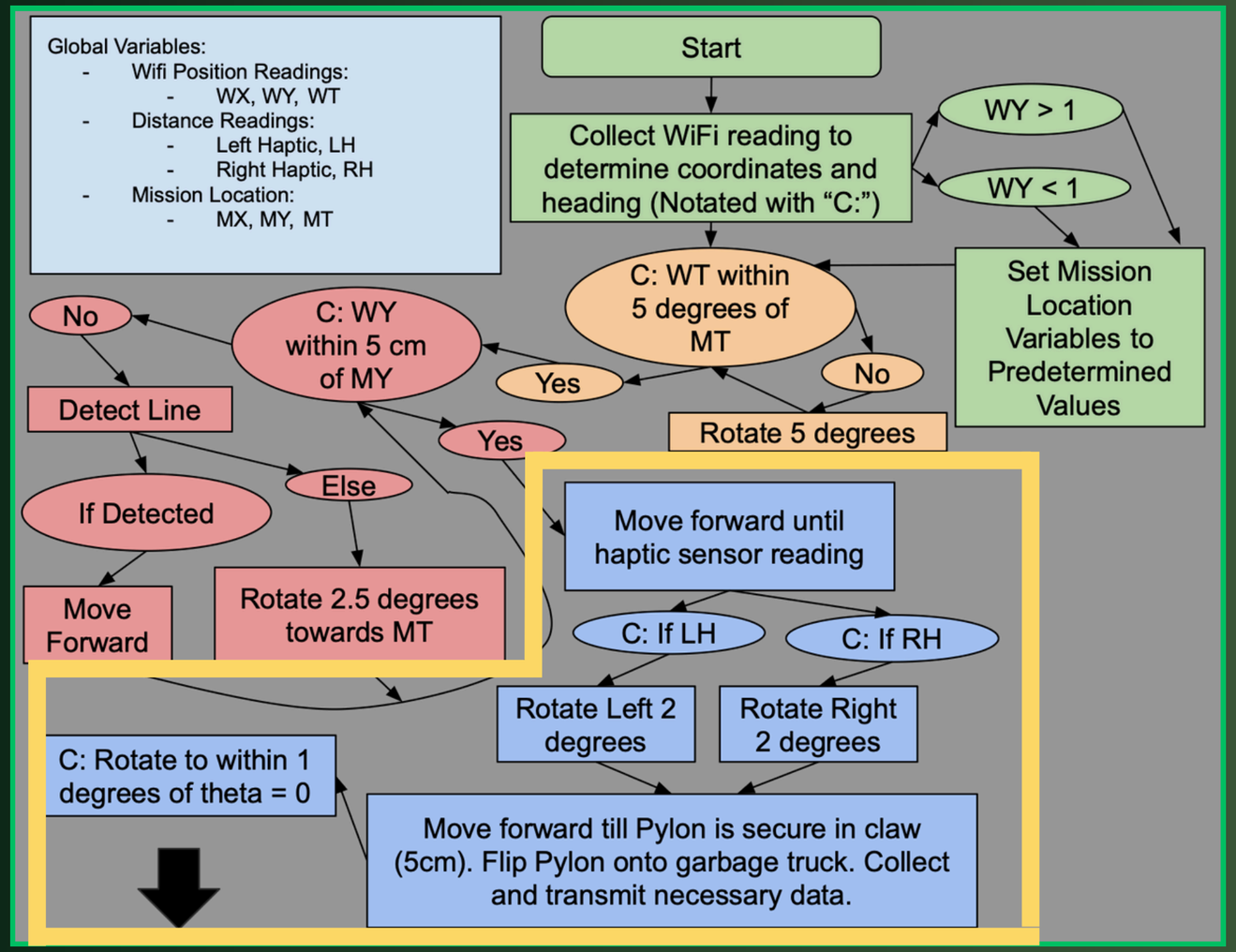
MISSION NAVIGATION FLOW CHART



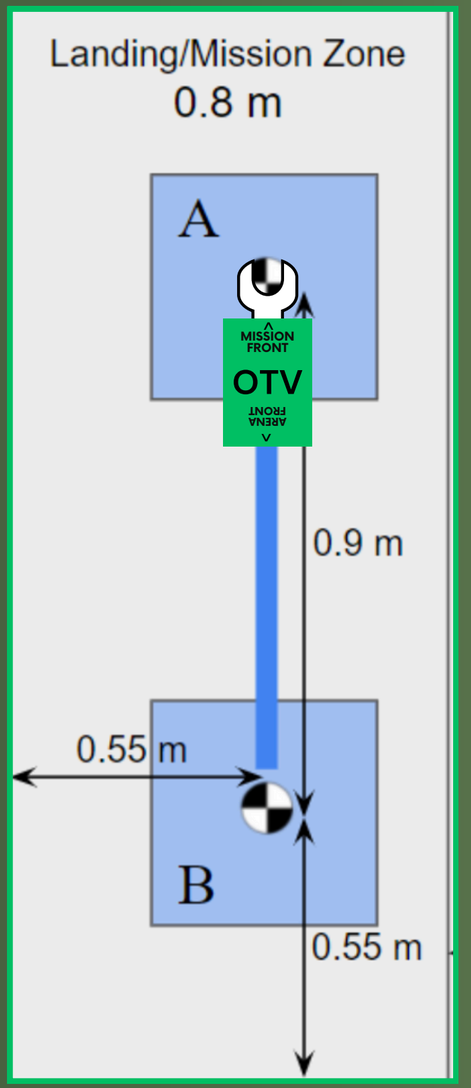
Coordinate:
(.55, .9)
Angle:
Theta = 0



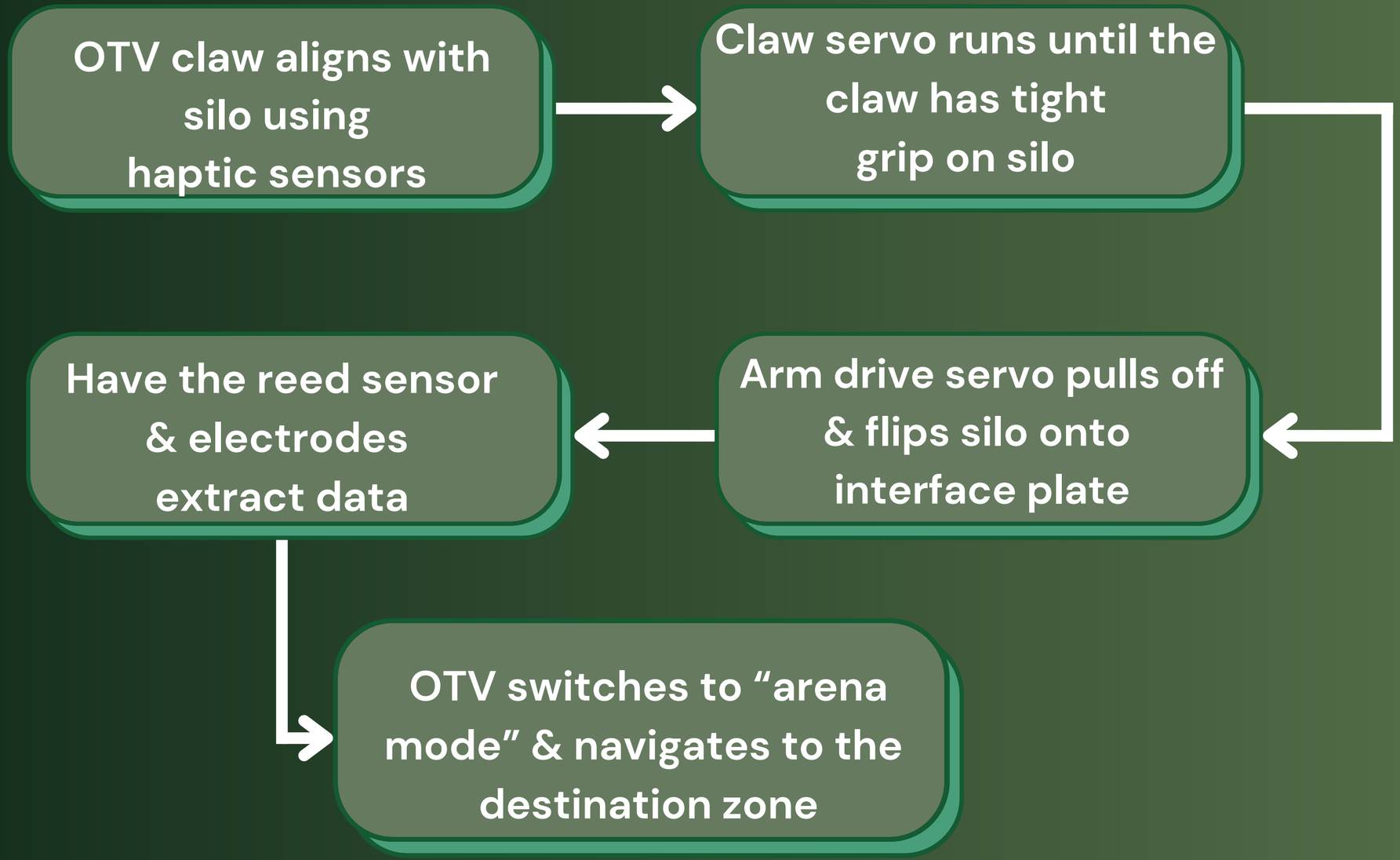
MISSION NAVIGATION FLOW CHART



Coordinate:
(.55, 1.45)
Angle:
Theta = 0



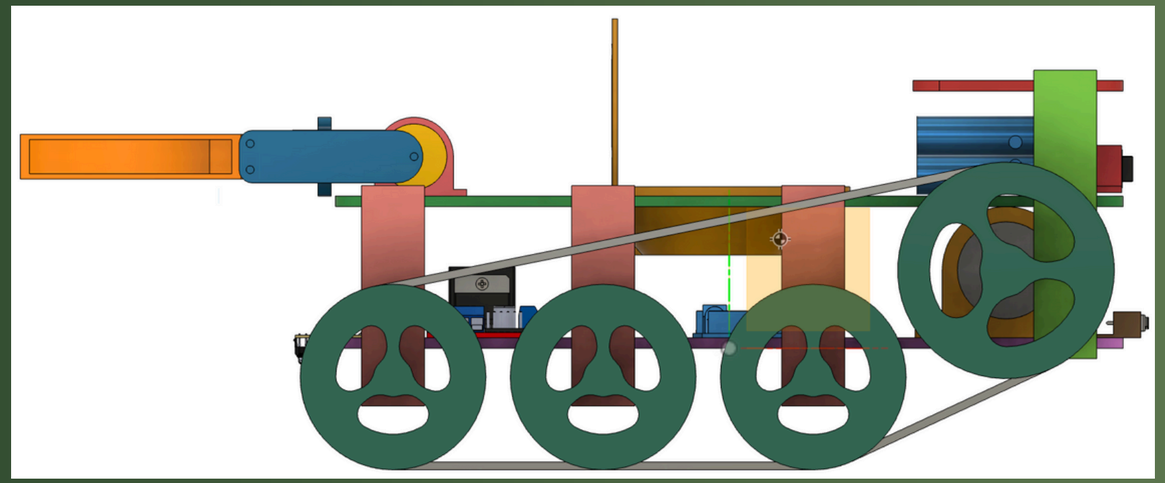
MISSION SYSTEMS FLOW CHART



PROPULSION METHOD

METHOD: TANK DRIVE

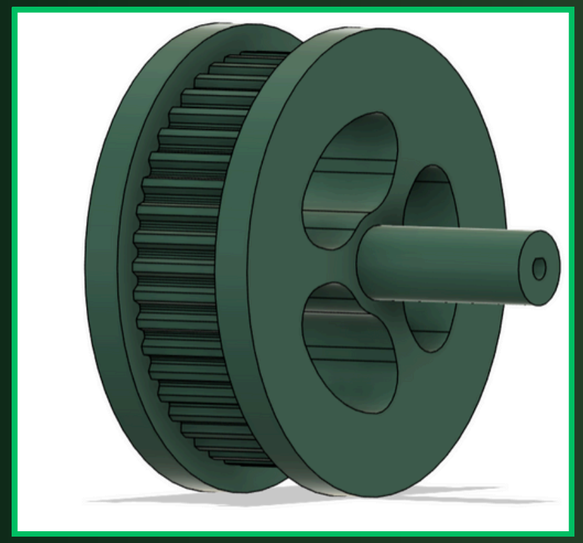
- Four wheels connected by a belt on each side
- Front two wheels are controlled by two motors
- Back six wheels are non-drive and smaller



WHEELS AND BELT

WHEEL SPECIFICATIONS

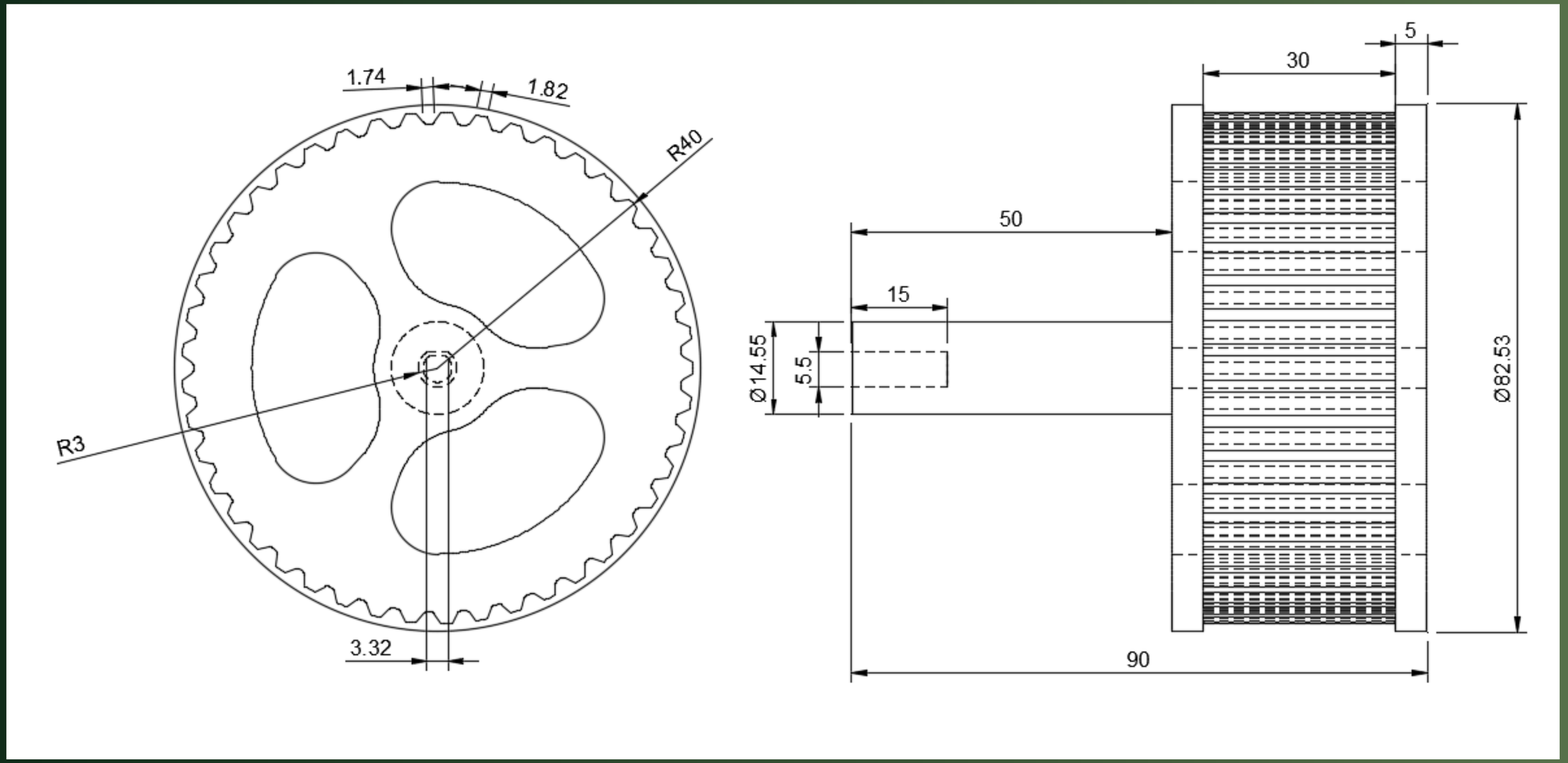
Front Wheel Radius [cm]	4cm
Stabilizing Wheel Radius	3cm



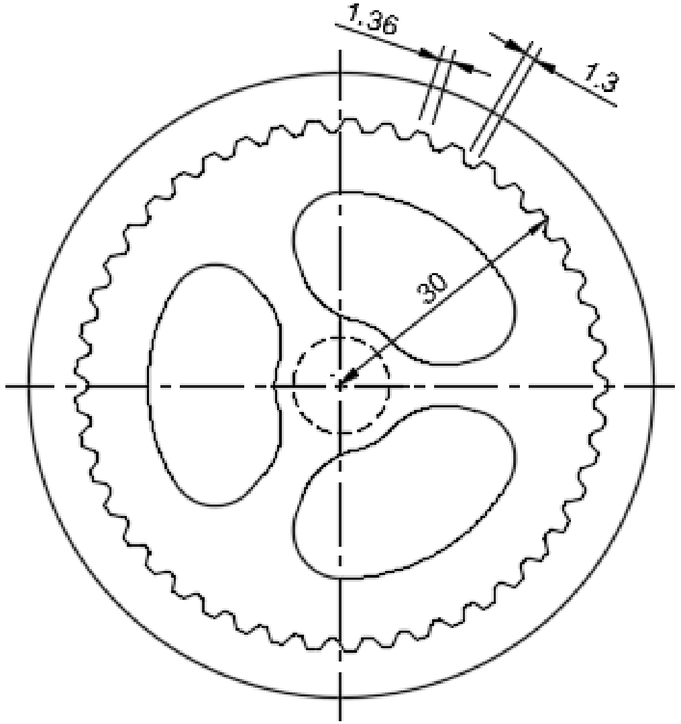
TREAD SPECIFICATIONS

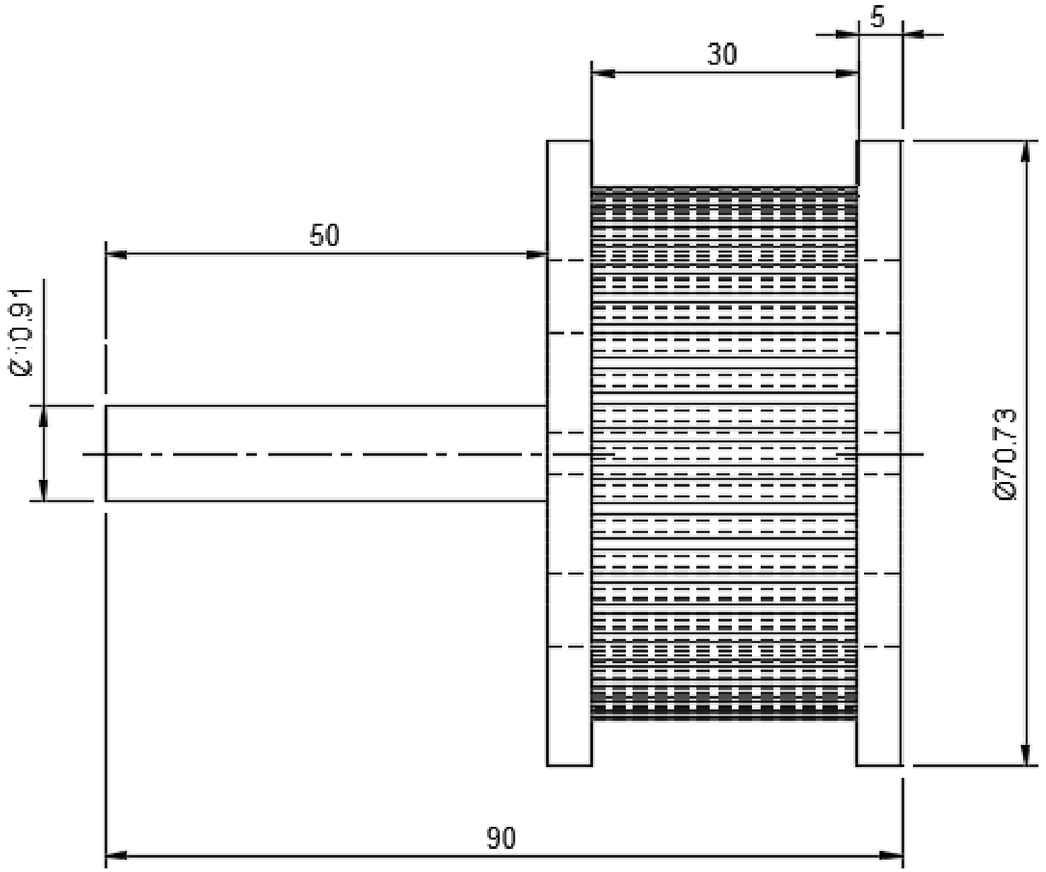
GT2 Pitch	2mm
Belt Tread	0.76mm
Length	200mm
Width	6mm
Belt Height	1.52mm

DRIVE WHEEL



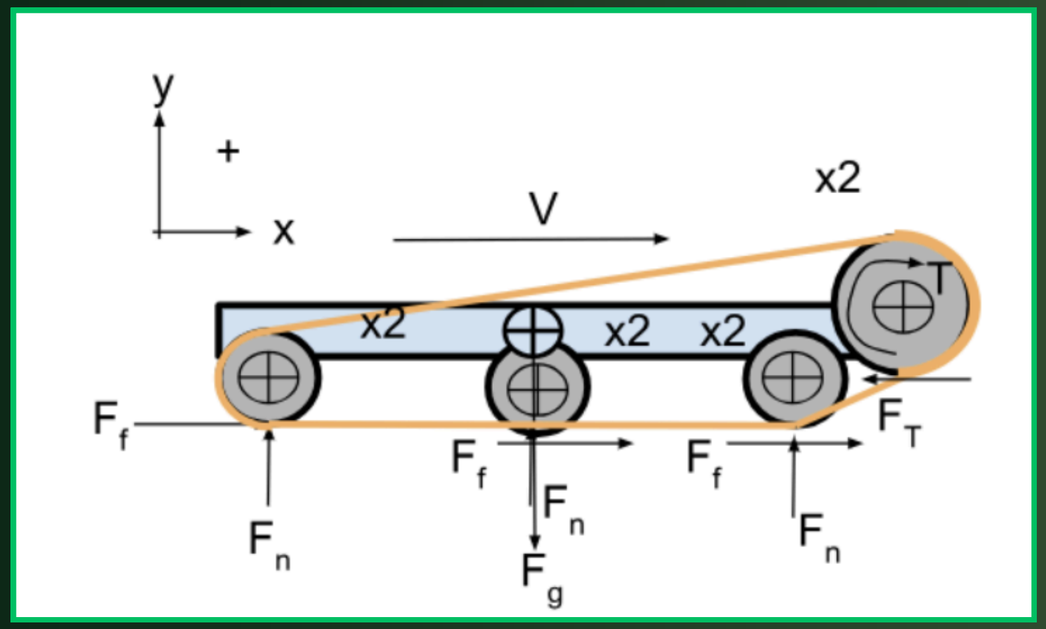
SUPPORT WHEEL





GENERAL TORQUE EQUATION

FREE BODY DIAGRAMS



EQUATIONS

m = *Mass of OTV*
g = *Gravitational Acceleration*
F_n = *Normal Force*
F_g = *Force of Gravity*

F_{RR} = *Friction Force*
C_{RR} = *Coefficient of Rolling Resistance*
F_T = *Force of Traction*
τ = *Torque of Motor*
r = *Radius of Wheels*

$$\Sigma F_y = ma_y = 0$$
$$\Sigma F_y = 4F_n - F_g$$
$$F_n = \frac{1}{6}F_g = \frac{mg}{6}$$
$$F_n = 6.54N \text{ with } 4kg$$

$$F_{RR} = F_n \cdot C_{RR}$$
$$C_{RR} = 0.7$$

$$\Sigma F_x = ma_x = 0$$
$$\Sigma F_x = 6F_{RR} - 2F_T$$
$$F_T = 3F_{RR} = (3)(0.7)(6.54N)$$
$$F_T = 13.73N$$

F_T = *Force of Traction*
τ = *Torque of Motor*
r = *Radius of Wheels*

$$\tau = F_T \cdot r$$
$$\tau = (13.73N)(0.04m)$$
$$\tau = 0.55Nm$$

EQUATIONS (CONT.)

SPEED

ω = Angular Speed of Wheels

v = Velocity of OTV

$v = \omega r$

$v = \omega(2\pi \text{ rad/rev})(1\text{m}/60\text{s})r$ = Velocity in m/s

CURRENT

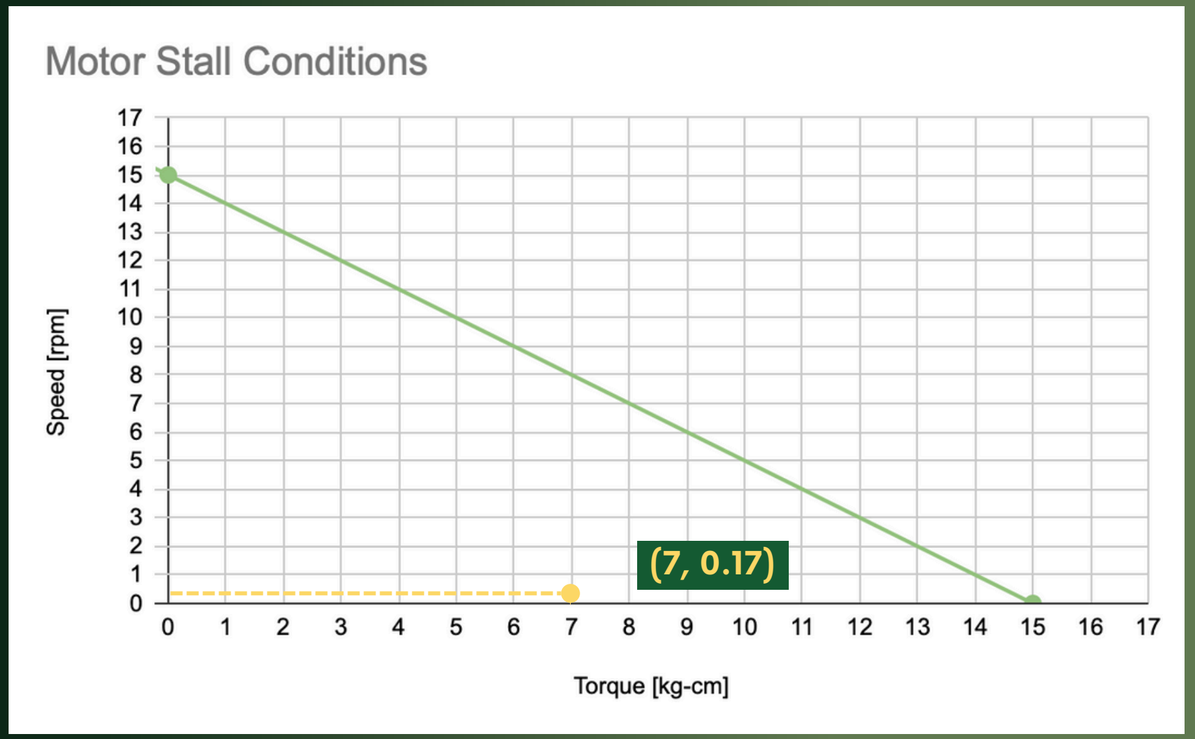
$$\frac{Rated\ Current}{Rated\ Torque} = \frac{x}{Required\ Torque}$$

$$x = (Required\ Torque)\frac{Rated\ Current}{Rated\ Torque}$$

$$x = (7)\frac{90}{15} = 42mA$$

$$x = Required\ current$$

MOTOR SELECTION



GREARTISAN MOTOR

The motor ensures a reasonable buffer between the expected and failure values

OPERATING GOALS

Linear Speed [m/s]	0.20
Current [mA]	42
Angular Speed [rpm]	0.17
Required Torque [kg-cm]	7.00

15.00>7.00 [kg*cm]

SPECIFICATIONS:

Rated Voltage [V]	12.00
Rated Current [mA]	90.00
No-Load Speed [rpm]	15.00
Rated/Stall Torque [kg-cm]	15.00

BATTERY SELECTION

Tenergy

Specifications

Weight	.225kg
Voltage	12v
Capacity	2000mAh
Max Continuous Discharge	2A
Chemical Makeup	NiMH
C-Rate	1C

BATTERY CALCULATIONS

TOTAL CURRENT DRAW

Component	Voltage(V)	Current(A)	Power(W)
x2 Drive Motors	12V	.3A	3.6W
x1 Dumping Motor	12V	.3A	3.6W
x1 Servo(claw)	5V	1.2A	6W
x1 Wifi Module	5V	.5A	2.5W
x1 Arduino Mega	5V	.5A	2.5W
x2 Bump Switches	5V	0	0W
x2 H-Bridge Motor Driver	12V	.2A	2.4W
x1 Kill Switch	12V	0	0
	68V	3.5A	26.5W

BATTERY CALCULATIONS

BATTERY LIFE

$$Energy = Power * Time = 26.5W * .167h(10\ mins) = 4.4255\ Wh$$

$$Required\ Capacity = \frac{Energy}{Battery\ Voltage} = \frac{4.4255Wh}{12V} = 369mAh$$

$$Expected\ Run\ Time = \frac{Battery\ Capacity}{Total\ Current\ Draw} = \frac{2Ah}{3.5A} = \frac{.571h}{60s} = 34.29\ minutes$$

C-RATE

$$C - Rate = \frac{Discharge\ Rate}{Battery\ Capacity}$$

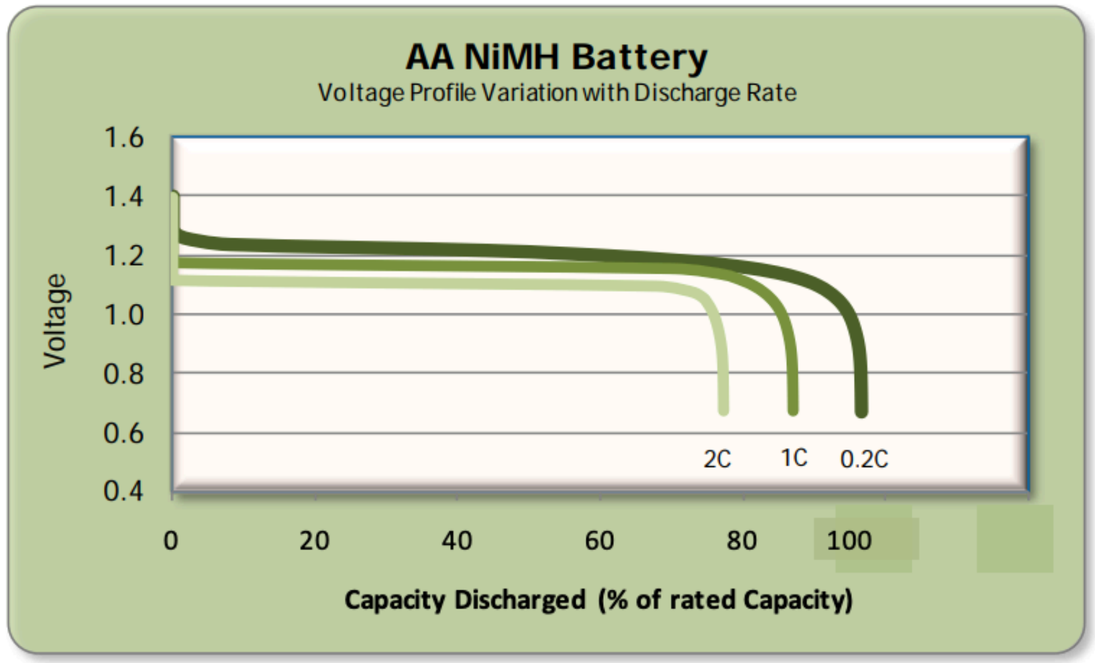
$$C - Rate = \frac{2A}{2Ah}$$

$$C - Rate = 1h^{-1}$$

BATTERY DISCHARGE GRAPH FOR DIFFERENT RATES

Since the 12V battery back consists of 10 cells in series, the voltage behavior will follow a general NiMH discharge curve

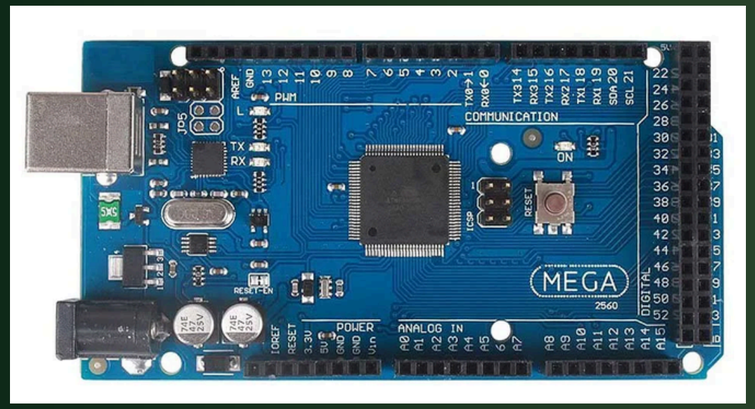
The effect of discharge rate on voltage profile is shown in (Fig. 8). There is no significant effect on the shape of the discharge curves for rates under 1C; for rates over 1C; both the beginning and ending transients consume a larger portion of the discharge duration.



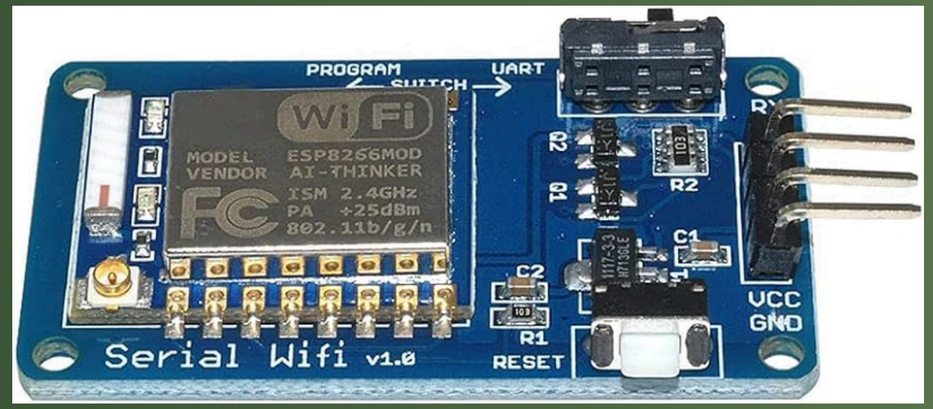
(Fig. 8) Voltage Profile Variation with Discharge Rate

https://data.energizer.com/pdfs/nickelmetalhydride_appman.pdf

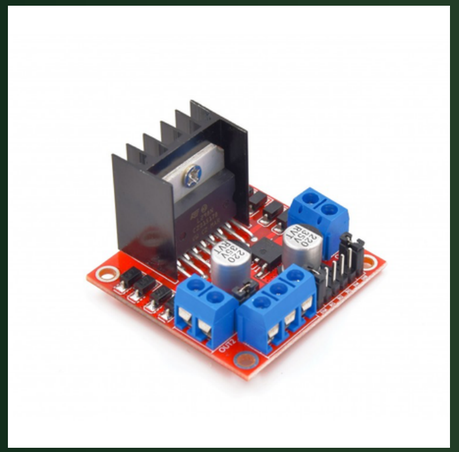
ELECTRICAL COMPONENTS



Arduino Mega



WIFI Module

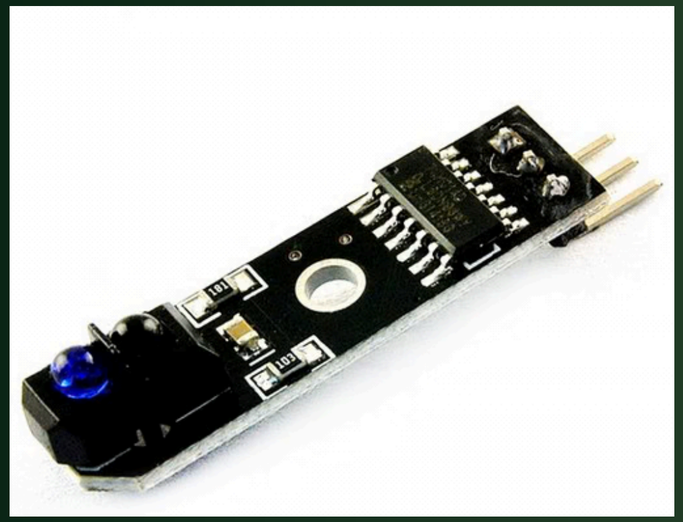


H-Bridge

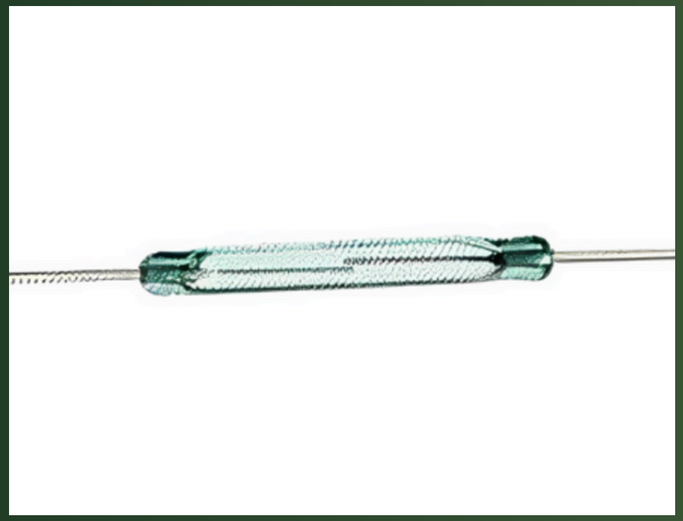
Motor

Servo Motor

ELECTRICAL COMPONENTS



Line Sensor

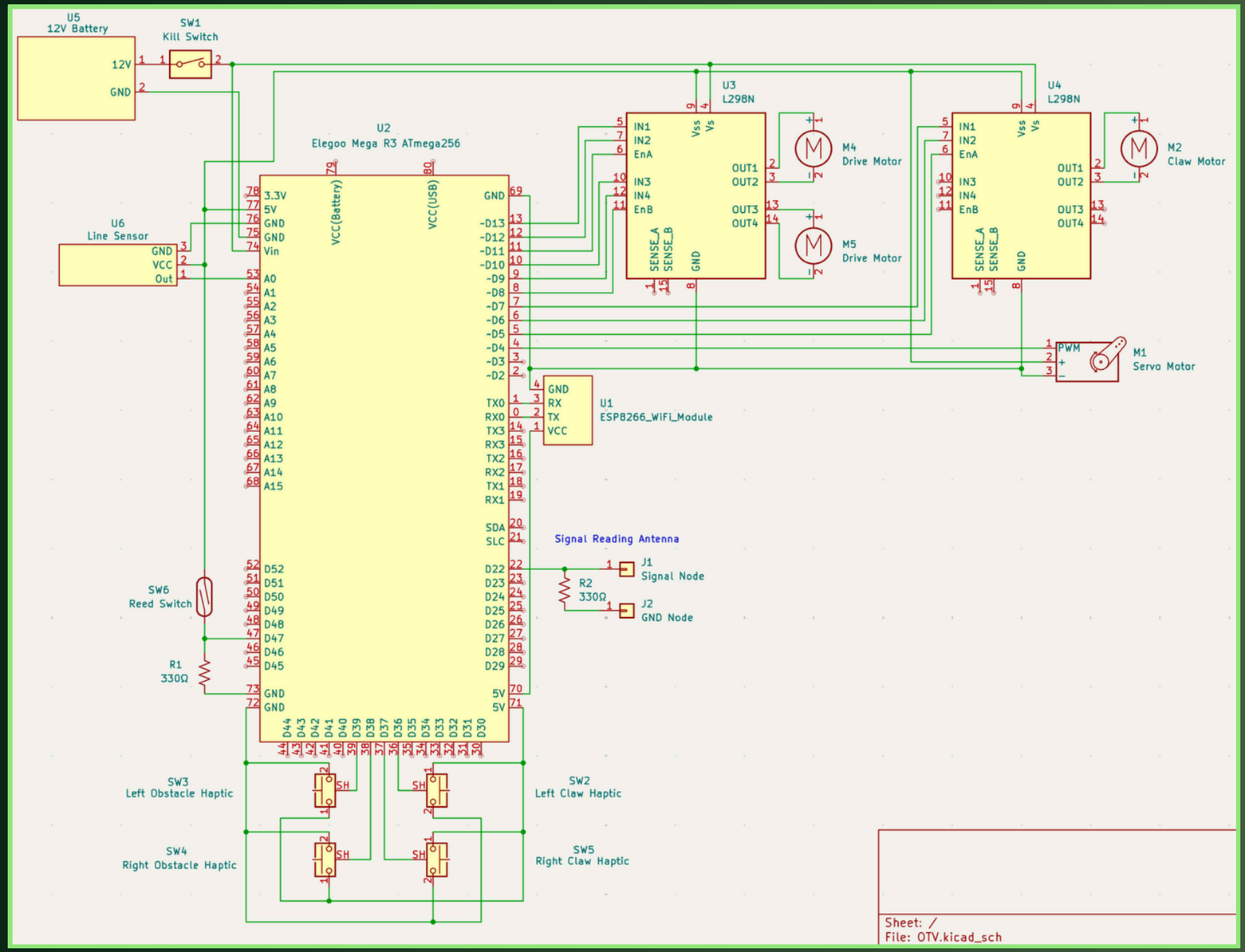


Reed Switch

Bump Switch

Kill Switch

CIRCUIT SCHEMATIC



ARDUINO PIN CHART

Component	Type	Arduino Pin(s)
L298 Motor Driver (Drive)	Motor Controller	~D8, ~D11, D9, D10, D12, D13
L298 Motor Driver (Mission)	Motor Controller	~D5, D6, D7
Servo (Mission)	Actuator	~D4
ESP8266 WiFi Module	Communication	TX0, RX0
Line Sensor	Sensor	A0
Reed Switch	Sensor	D47
Signal Reading Antenna	Sensor	D22
Left Obstacle Haptic Switch	Sensor	D39
Right Obstacle Haptic Switch	Sensor	D38
Left Claw Haptic Switch	Sensor	D36
Right Claw Haptic Switch	Sensor	D37
Power Pins	Power	Vin, 5V, GND

POWER HANDLING STRATEGY

- PWM (Pulse Width Modulation)
  - Manipulate and control electrical components by cycling voltage width to get desired output on components
- H-Bridge Motor Drivers
  - Simplifies electrical wiring, power amplification, and coding of motors
- Arduino MEGA
  - Expands I/O pin options
  - Easier to control more components

BUDGET SHEET

Product	Amount	Cost [$]	Mass [kg]
Elegoo MEGA R3 ATmega 2560	1	$22.99	0.064
BOJACK L298N Motor DC Dual H-Bridge Motor Driver	2	$13.98	0.080
Tenergy NiMH Battery Pack 12V 2000mAh High Capacity Rechargeable Battery	1	$21.99	0.255
MS0850502F030P1A Snap Action Switch	2	$2.70	0.002
RA1113112R Rocker Switch	1	$0.71	0.003
TCRT5000 Line Follower Sensor	1	$1.75	0.040
Reed Switch	1	$0.40	0.001
MG995 Servo Motor	1	$4.25	0.055
Greartisan DC 12V 15RPM Motors	2	$30.00	0.444
Pololu 99:1 Metal Gearmotor 25Dx54L mm HP 12V	1	$28.95	0.091
Other Electrical Components (ex. Wires, Resistors, WiFi)	N/A	$10.00	0.050
3D Print Spacers	8	$0.50	0.100
Recycled PLA	N/A	$1.00	0.560
3D Print Mission Task Components	N/A	$0.50	0.100
3D Print Wheels	8	$0.50	0.160
GT2 Timing Belt Closed Loop Rubber Belt	1	$8.00	0.020

Total	
Cost	$148.22
Mass [kg]	2.025

TEAMWORK

In team meetings, we are extremely productive and try to include all teammate’s ideas and opinions.

Our team chose our design and theme using bracket method votes, deciding on Oscar the Grouch and an OTV that functions similarly to a garbage truck.

We need to work on effective communication and trusting each other to do their parts.

Many of us are working in an area that is unfamilair to us, thus improving our understanding across disciplines and allowing us to combine our strengths to help each other.

THANKS FOR LISTENING