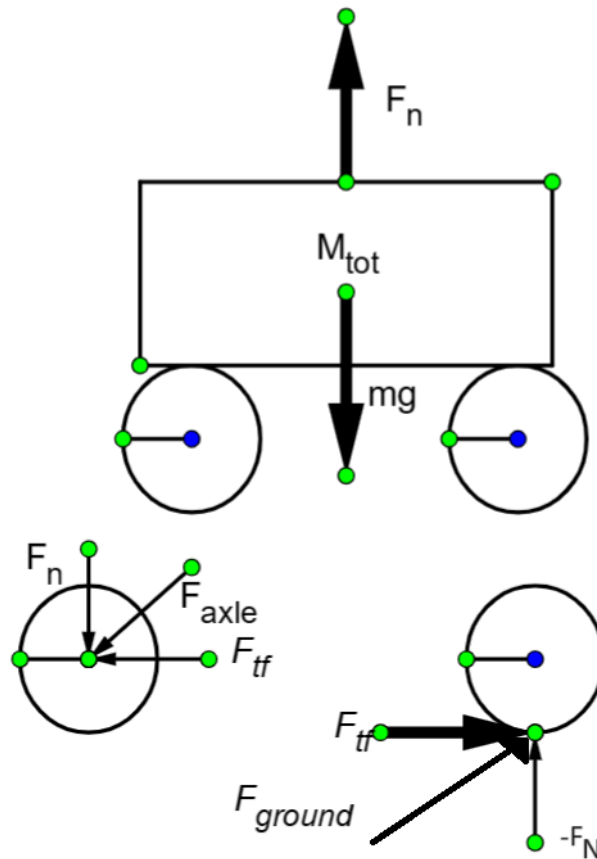


### Design Brief 3: Propulsion Modeling

#### Main Propulsion Details

- 4 motor, 4 wheel direct drive
- Wheels are 80mm in diameter and 36 mm wide
- Motors are 12V, 36 RPM max at no load, 290 oz.in stall torque at 1.6A.
- Predicted motor behavior:

#### Predicted Motor Behavior



OTV Free-body diagram

#### Motor & Torque Calculations

##### *Equilibrium Equations*

- $\Sigma F_x = 4F_T - 4F_{RR} = 0$ 
  - $F_{RR} = (1/4)(r)(g)(w+b_{\max})(0.02) = 0.0037523 \text{ N-m (per wheel)}$
  - $F_T = F_{RR}$
- $\Sigma F_y = F_N - mg = 0$ 
  - $F_N = 9.81*(1.62+0.295) = 18.79 \text{ N}$
  - $F_{Nw} = F_N / 4 = 4.7 \text{ N (per wheel)}$

#### *Torque Required for Straight Driving (Constant Velocity)*

- 0.0037523 N-m

#### *Torque Required to Start Moving*

- $(1/4)(r)(g)(w+b_{\max})(0.9) = 0.1688531 \text{ N-m}$

#### *Ideal RPM (target velocity is 10 cm/s)*

- $(10 \text{ cm/s}) / 4 \text{ cm} = 2.5 \text{ rad/s} = 23.9 \text{ RPM}$

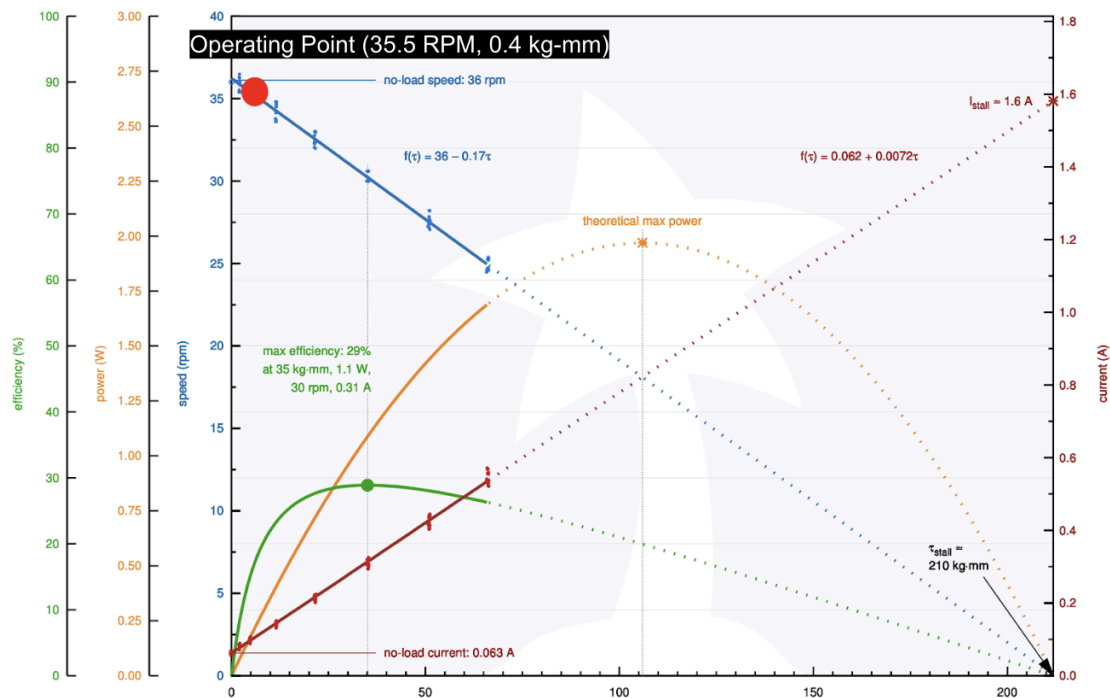
With these calculations in mind, we decided to purchase a motor from pololu. Below are the for said motor specs:

#### *Motor Specs*

- 36 RPM no load performance
- 0.063 amps no load current
- 210 kg-mm stall torque
- 1.6 amps stall current
- 12 volt
- 20 mm diameter x 47.7 mm long
- 47 grams

The motors that we selected have more than enough torque to move our OTV, which is beneficial because strafing is much more demanding than moving forward. This motor also operates relatively close to our target velocity, so our OTV will not be moving too fast. Also, because we are operating close to the low end of its torque, the power draw is minor, so it will not be too taxing on the battery. It will operate at around 35.5 RPM & 0.4 kg-mm, and will have a power draw of around 0.08 amps. Converting 35.5 RPM to linear velocity considering 80 mm wheel diameter gives us around 15 cm/s, which is slightly fast but still in our desired range. Below is a motor characteristic graph.

*Motor Characteristic Graph, created by [Pololu](#)*



### **Actual Motor Behavior**

*Observed Operating Linear Speed: 13.4 cm/sec*

*Observed Angular Speed = 3.35 rads/s  $\rightarrow$  32 RPM*

*Actual Torque =  $\sim 0.38$  kg\*mm*

### **Expected Vs Observed Comparison Analysis**

The OTV's motors performed very similarly to how we predicted it to. The operating linear speed was only 1.6 cm lesser than expected, meaning that our calculations were accurate.