Dyno-RAPTOR: Dynamometer Rover Assessment Platform for Torque, Output, and Response

Cory Duvall[1], Brandon Clabaugh[2], Dr. David Akin[3], Dr. Mary Bowden[3]
[1]University of Maryland Eastern Shore, Princess Anne, MD 21853
[2] University of Maryland College Park, College Park, MD 32310
[3]382 Technology Drive, College Park, MD 20742

Background:

Commercial off-the-shelf (COTS) hoverboard motors provide a low-cost high-torque drivetrain option for robotic platforms such as RAVEN (Robotic Assist Vehicle for Extravehicular Navigation). However, to use these motors successfully, it is necessary to accurately characterize their motor output (i.e. torque vs. angular velocity) under actual loading conditions. This requires a specialized, reproducible testbed to evaluate performance, assuring that the motors can satisfy the operational demands of the rover.

Hypothesis/Objective:

- **Objective:** To Design dynamometer system to test motor torque and motor angular velocity from motors of a hoverboard.
- **Hypothesis:** The hoverboard motors will be able to be reused for rovers such as RAVEN (Robotic Assist Vehicle for Extravehicular Navigation).

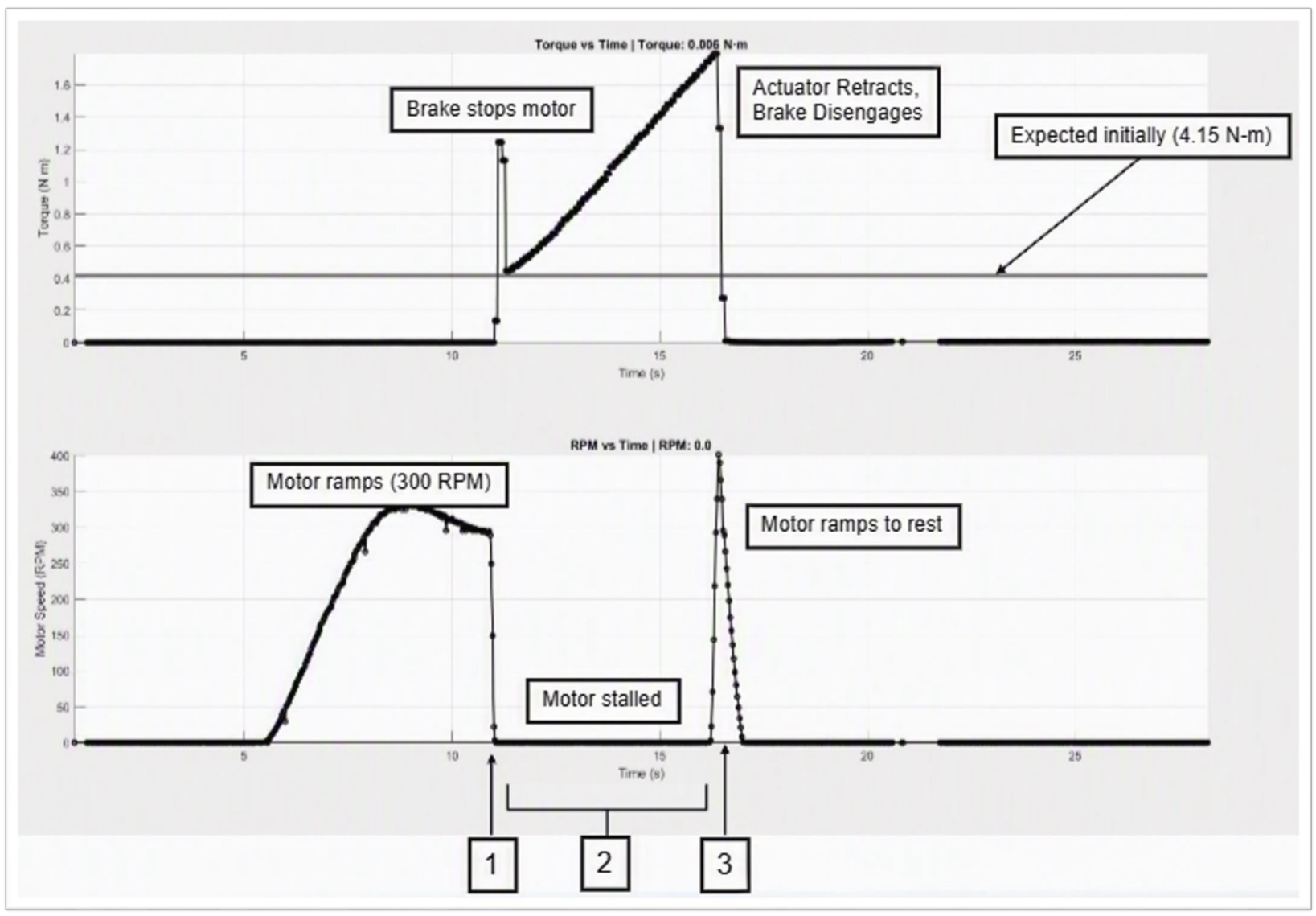
Results Summary:

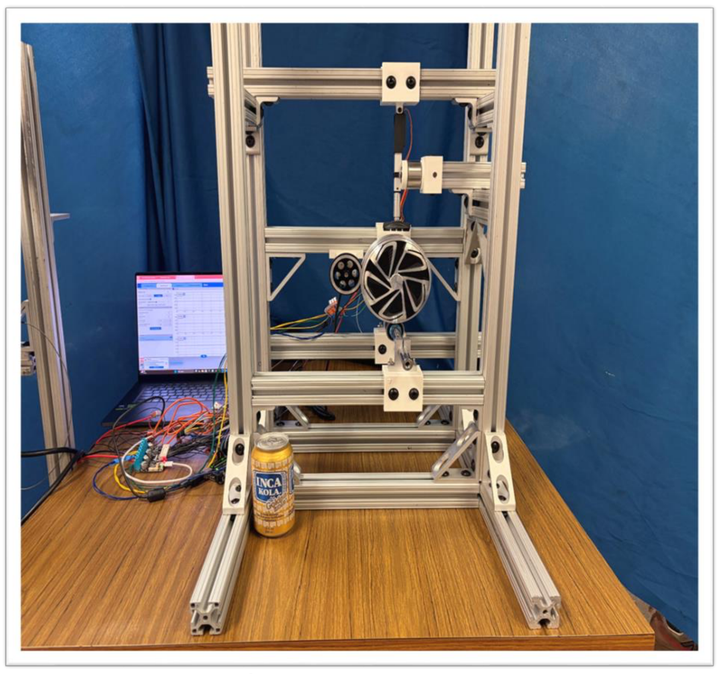
- Real time data successfully acquired, graphing continuous torque (τ) and angular velocity ("RPM") during automated linear actuator braking cycles.
- Experimental tests showed that COTS hoverboard motors had a maximum capacity of 3.23 N"·"m, only 6.13% of the 52.65 N"·"m required to drive the 600lb RAVEN rover up a 15 degrees incline.
- The brake actuator stalled the motor from 300" RPM“ to 0" RPM“ and the torque increased linearly over 5" seconds" as the controller ramped up phase current to maintain setpoint speed.
- Release of the brake load resulted in an overspeed burst 350 RPM and an immediate current surge, and a secondary torque peak and transient mechanical recoil.

Methodology:

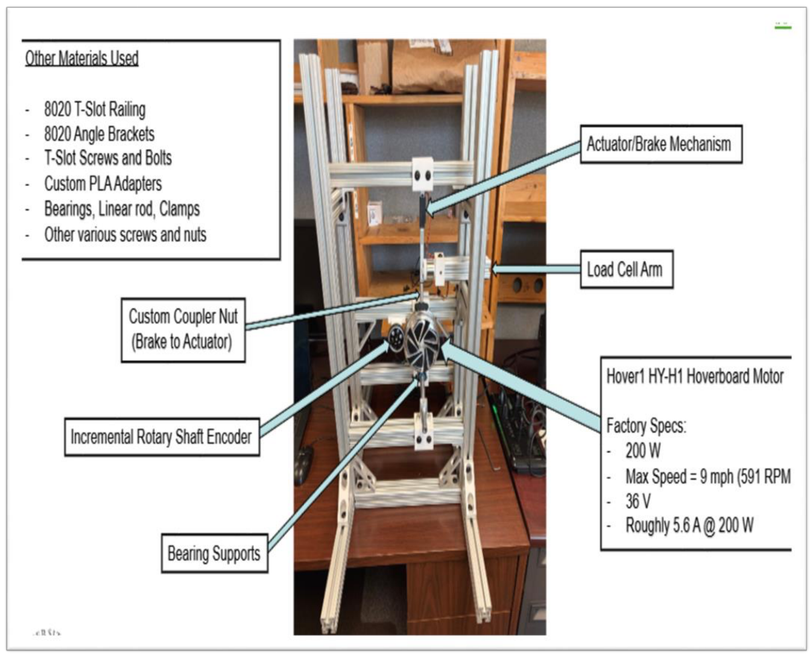
- Disassembled Hover 1 Hy-H1 hoverboard to extract 9mph dual 200W motors and hardware for repurposing.
- Designed missing structural and mounting parts using Siemens NX CAD.
- Integrated actuator, ODrive S1 controller, and power supply to apply loads and monitor wheel motor angular velocity.
- Wired load cell with HX711 amplifier to Arduino Uno for force sampling and torque calculation.
- Developed custom C++ Arduino code to acquire load cell and encoder data.
- Used MATLAB for data analysis, torque/velocity plotting, and signal processing.

Graphs: Torque V.S. Time Top / Bottom RPM V.S. Time

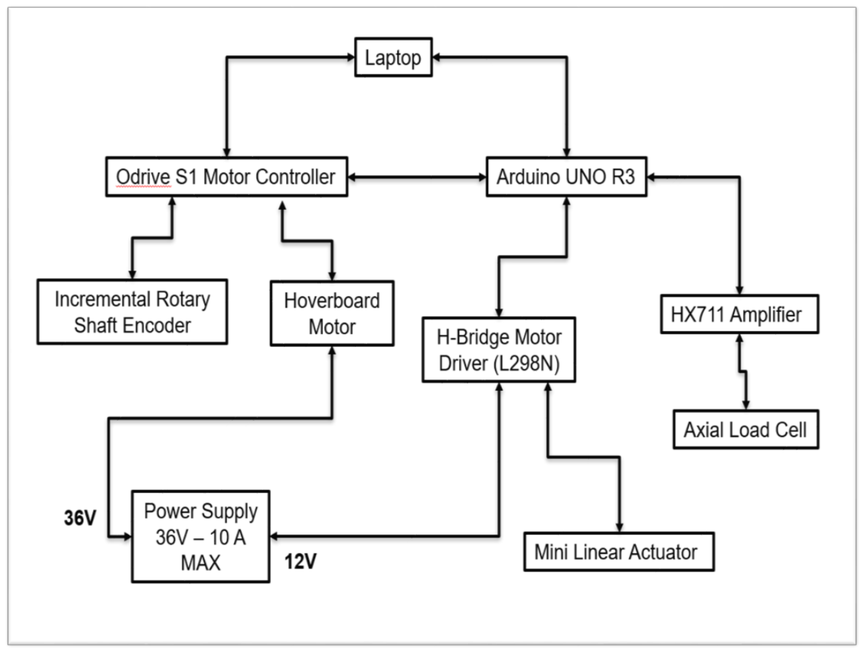




Final Testbed



Dynamometer



Hardware

Conclusion:

Dyno-RAPTOR tests showed that COTS hoverboard hub motors lack the power for large rovers like the 600 lb RAVEN, delivering 3.23 N·m torque versus the 52.65 N·m needed for a 15° slope. However, they suit smaller rovers. Dynamic testing revealed a controller issue causing current surges and overspeed bursts 350 RPM during load disengagement, leading to torque recoil. Scaling motors for larger platforms, future work must integrate a high-ratio gearbox (at least 17:1) and active software braking.