Ergonomic Wheelchair

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Problem Statement

Develop an electrically assistive propulsion system that bridges the gap between traditional mechanical wheelchairs and motorized wheelchairs for a client with a medical condition that causes decreased muscle coordination and strength.

Design Objectives

Mechanical Actuation System

Physical input from the user mimicking the motion of a chest press exercise

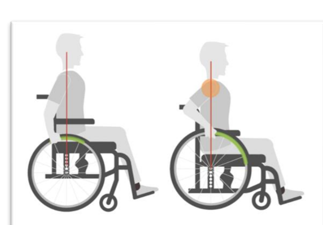
Electrical Assistance

DC motors to power friction-drive rollers mounted on the rear wheels of the wheelchair

Customized User Interface

Button control system for steering and a mode for complete electric operation with no physical user input required

Existing Solutions

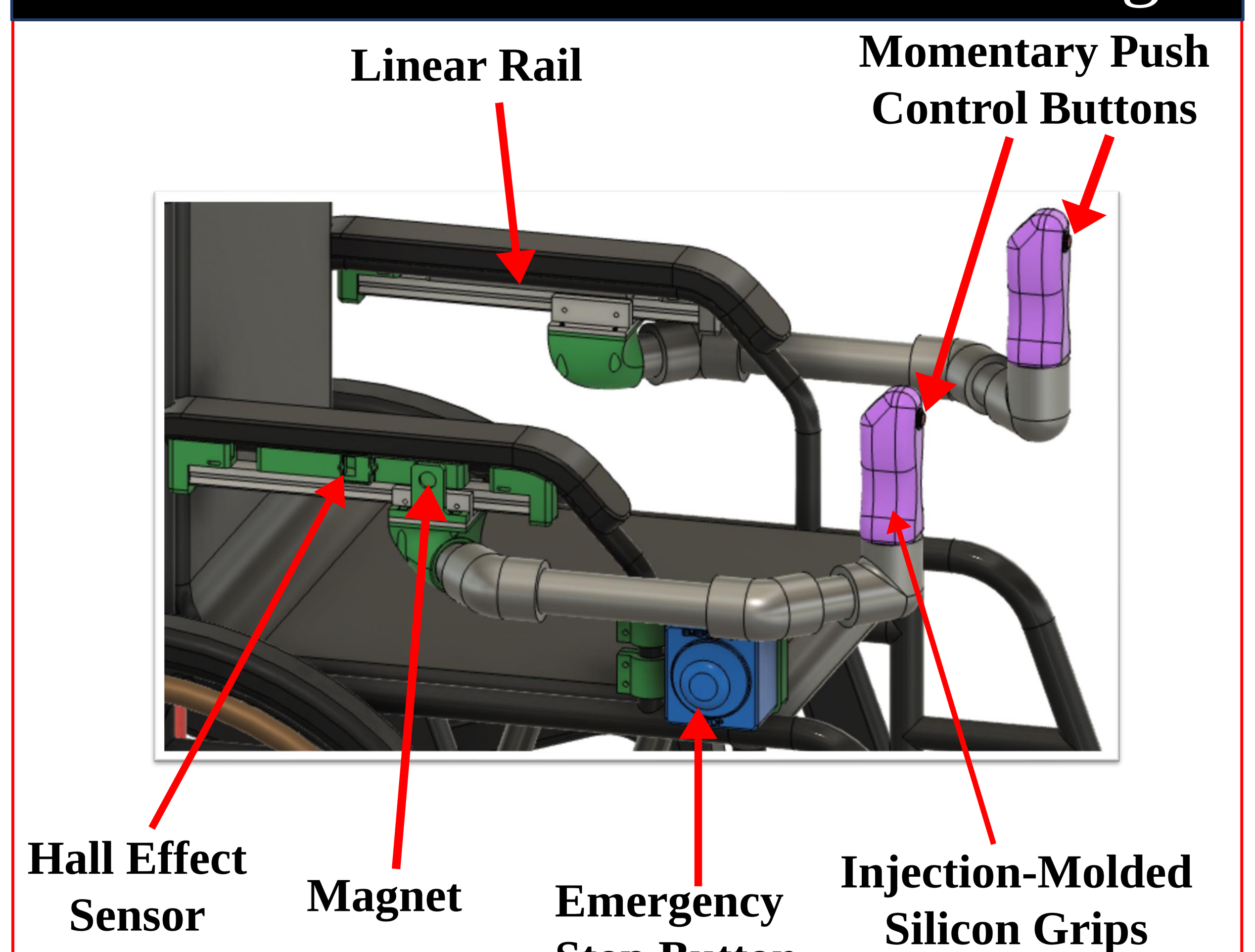


Conventional Hand-rim Manual Wheelchair
Pro: Greater affordability, common-place
Con: High strength requirement, awkward to push oneself

Mountain Trike
Pro: Resolves ergonomic shortcoming of convention hand-rim wheelchair
Con: More expensive, still would require too much strength from our client

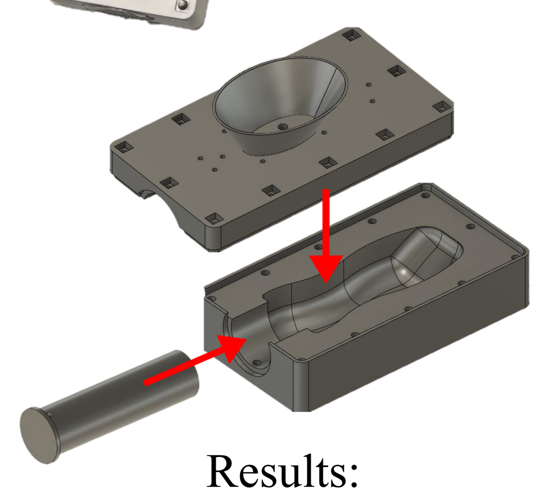
Element14 Arduino Project
Pro: Low strength required (fully electric), affordable
Con: No physical exercise, moves too slowly

Final Mechanical Actuation Design

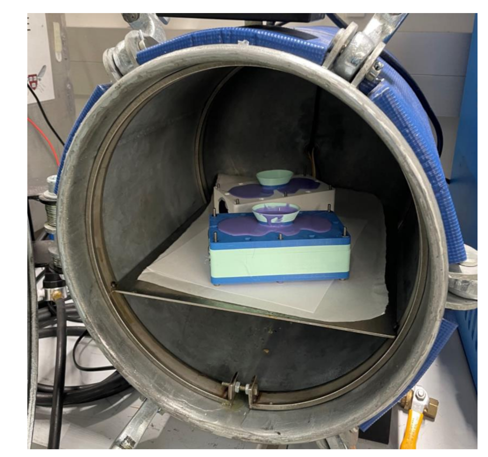


Manufacturing

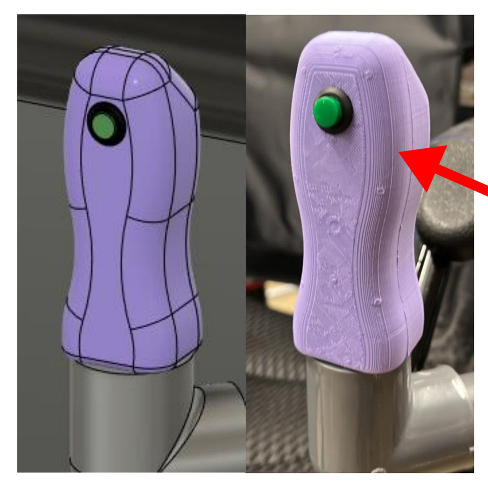
Designed molds and utilized **silicone injection molding** to make custom handles for client's physical needs.



Molds are cured at **50C** within a pressure chamber to prevent air bubbles from forming



Results:

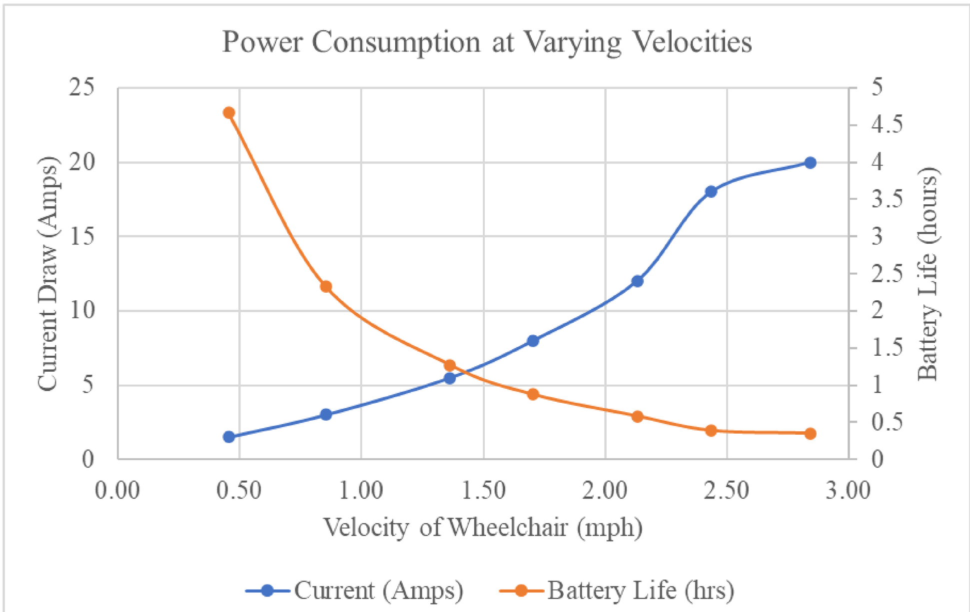


CAD Final

Green trigger button designed to be at the back of handle to prevent high needs for dexterity when operating.

Battery and Charger Analysis

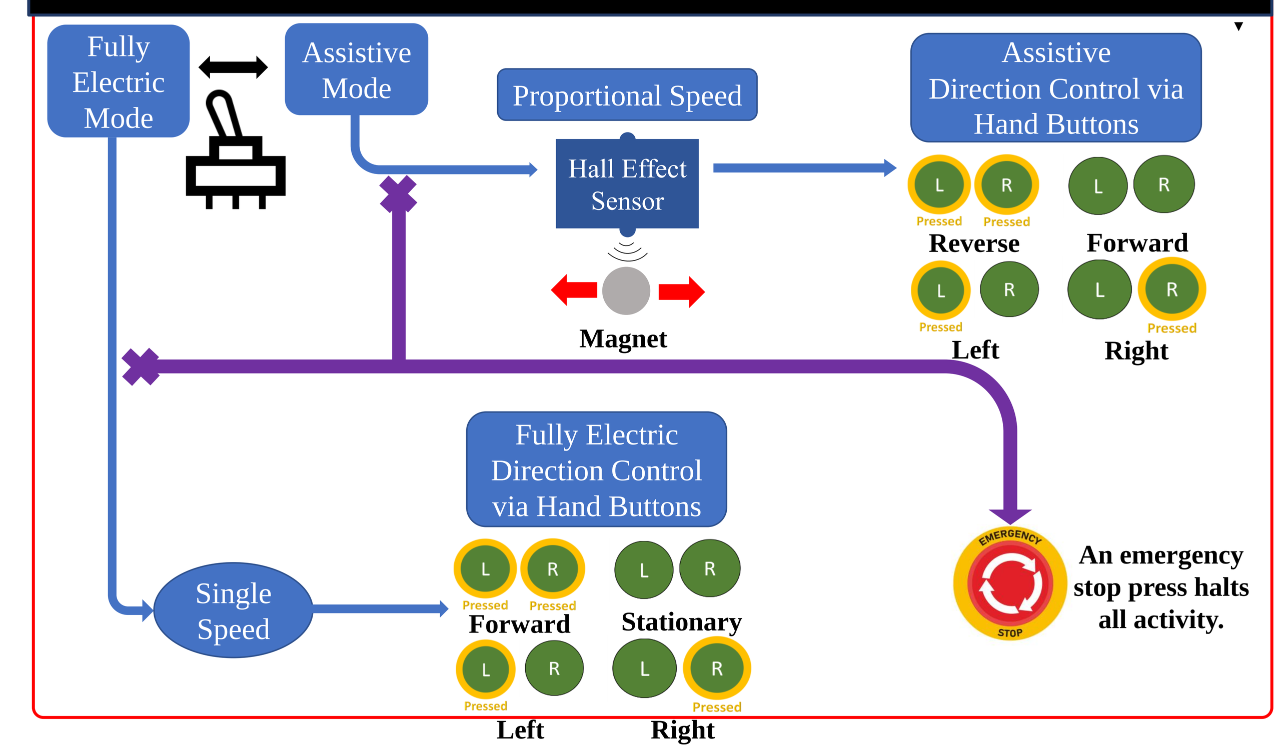
Wheelchair is powered by a 12 Volt, 7 Amp-hour, rechargeable lead-acid battery.



Fully Electric State → Operates at 1 mph for ~2 hours
Manual Input → Max Speed at 3 mph for ~20 minutes

Battery Charging
Utilizes a 12 Volt, 10 Amp Charger which plugs into port on electronics enclosure.

User Interface



Results

Our client tested the wheelchair!

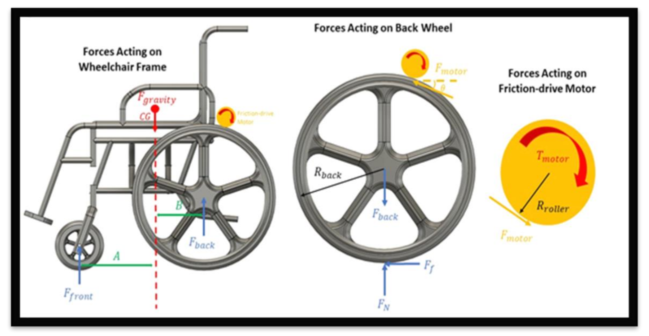
Client feedback highlighted our successes and helped steer the team towards further iterations and plans for future work!

Max Speed: 3 miles per hour	**Weight Capacity:** 220lbs
Battery Life: Varies from 20 minutes to 2 hours depending on set speed	

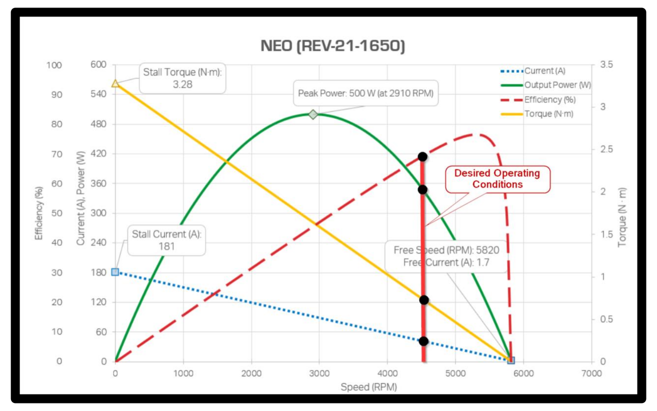
Motor Selection

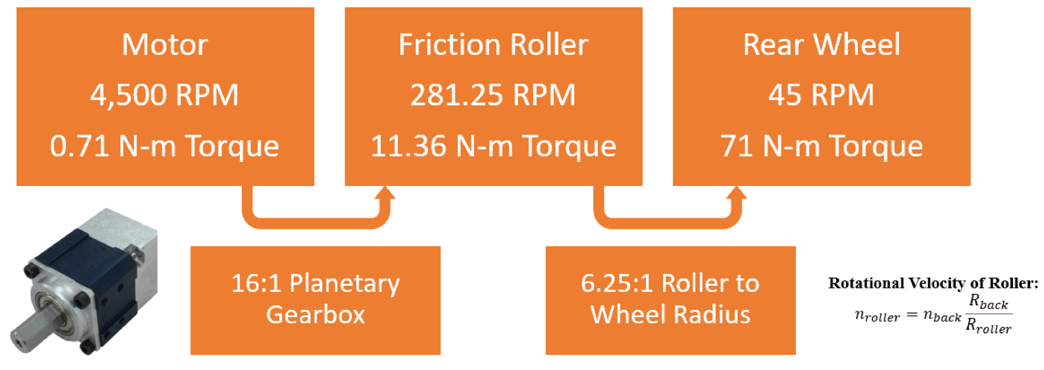
The motors selected by the team had to have enough power to propel Noah in his wheelchair at standard walking speeds of approximately 3 miles per hour. Conservative power requirement calculations showed we **needed 137 W from the motor and 28 N-m of torque.** The team opted for Vex NEO Brushless DC motors, each with a max power output of 500W.

Desired Motor Operating Range:
- 4,500 RPM
- 350W Power
- 69% Efficiency
- 0.71 N-m Stall Torque



Gearbox Selection
To transition from the 4,500 RPM of motor to goal 45 RPM of rear wheel and achieve required torque, the team opted for a 16:1 gearbox.

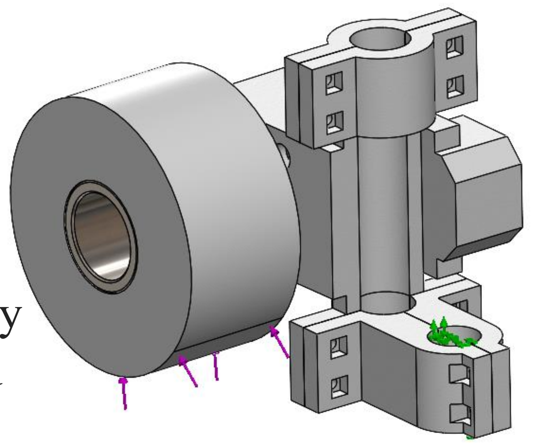


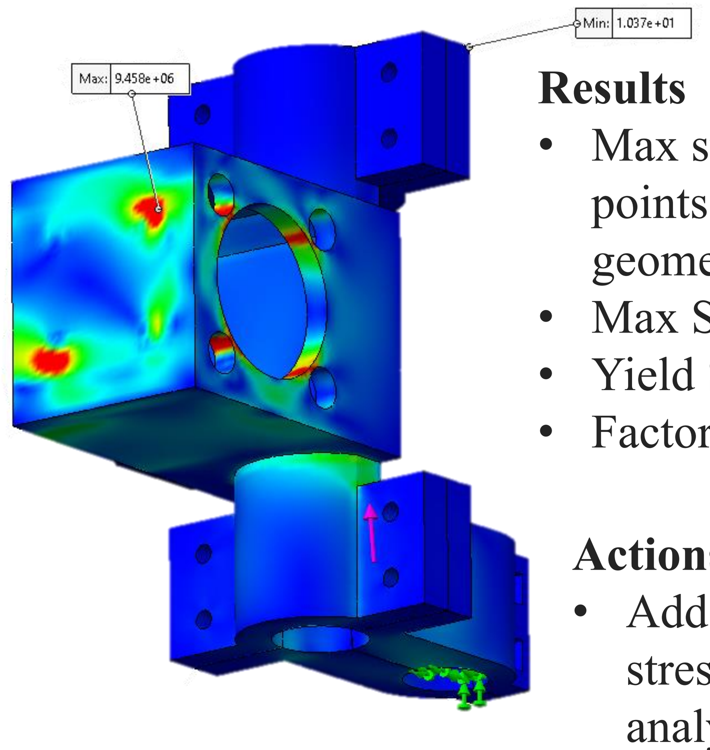


Finite Element Analysis (FEA)

A stress evaluation was conducted on the 3D printed motor bracket design using SolidWorks Simulation with the goal of assessing if the geometry could withstand operation.

Analysis Setup
- ~**9 lbf** acting on section of roller that interferes with wheelchair wheel
- Roller, gearbox, and motor assembly treated as rigid body
- Bracket fixed where clamped to wheelchair
- Interfacing fastened brackets and motor fastened points treated as bonded faces





Results
- Max stress found at fastening points and rapid changes in geometry thickness
- Max Stress: **9.5 MPa**
- Yield Strength of PLA: **40 MPa**
- Factor of Safety: **4.2**

Actions Taken:
- Added more fillets where high stress accumulated in the analysis
- Added another horizontal bracket support for the motor to prevent torque at fastening points

Potential Future Work

Material Selection

Manufacture frame using a material that is stronger than PLA and has a greater lifetime

Braking System

Add a mechanical attachment to instantly apply a brake to the wheelchair within Noah's strength requirements

Electric Control

Improve response time to changes in direction and change either the battery or power transmission to reduce operating current.

Mechanical System

Change from a friction drive power transmission to a belt drive directly attached to the wheel to eliminate slipping

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