Collapsible Electric Longboard

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Motivation

- Exploring Alternative/Emerging Transportation
- Reducing Car Dependency
- The Last Mile Solution → Promoting multimodal transportation
Mechanical Technical Design
Prototype Designs

Mesh or Hinges

Interconnecting Beams

Hinges + Structural Rods

Self-Connecting Hinges

Ratchet Wire Deck
Final Prototype Design

Maple Wood & Plywood

Steel Alloy

PLA Plastic Hinges, 7% Infill

Carbon Fiber

18-8 Stainless Steel
Stress Analysis

Analyses assume a weight of 250 lb.

1. Shear of structural rods → Factor of Safety (FS): 46.5

2. Bending of structural rods → FS: 8.61

3. Compression of PLA under bolt pretension → FS: 2.47

4. Compression of PLA under structural rods → FS: 5.69

5. Fatigue of structural rods → 500 million load cycles (~equivalent to 171,000 years, 2 commutes daily and 4 load cycles per commute)
### Testing

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Skateboard:</td>
<td>20 lbs</td>
</tr>
<tr>
<td>Volume of Skateboard:</td>
<td>1312.5in²</td>
</tr>
<tr>
<td>Deflection:</td>
<td>0.125” at rest. 1.775” with weight at center.</td>
</tr>
<tr>
<td>Top Speed:</td>
<td>15.2 mph</td>
</tr>
<tr>
<td>Acceleration on Flat Ground:</td>
<td>0.548 m/s² or 1.23 mph/s</td>
</tr>
<tr>
<td>Mile Range:</td>
<td>3.88 miles*</td>
</tr>
<tr>
<td>Energy Usage:</td>
<td>22.2 Wh/mile*</td>
</tr>
</tbody>
</table>

*with testing speeds of 6-11 mph*
Software Technical Design

Front End (Presentation)
- Swift, Sketch and Supernova Studio
- User Interface
- Screen Transitions
- User Input Collection

Back End (Data Access)
- Swift and Firebase
- Real-time Speed and Distance Calculations
- Account Info and Trip History
- Database Queries
Firebase Advantages:

- JSON Database (unstructured data stored in hierarchical key-value pairs)
- Built-In Authentication
- Swift Application Programming Interface
The electronic speed controller (ESC) is the brains of the board. The ESC reads and translates radio signals from the remote and routes battery power accordingly to drive the motor. This board is running on the VESC open-source ESC software, which implements regenerative braking for the board.

A 6S2P lithium-ion battery powers the board. The performance measurements for this board are based on this battery size, but a full production model will include a larger 12S battery, which will greatly increase both the top speed and range.
1. Ride
Trip statistics, updated live as users ride.

2. User Profile
Store past rides of users after account registration.
iOS App Significance

1. Improve User Experience
   Give users a graphical platform to check their skateboard and ride statistics.

2. Research Data Platform
   Set up platform to collect transportation data, useful for alternative transportation research.
Societal Impacts

How much time does the average American spend sitting in traffic while commuting to an urban center, per year?

42 hours
Reduced Traffic Congestion

Economic
- Improved productivity from time savings

Social
- Less frustration

Environment
- Reduced pollution from vehicles and from idling in traffic
Social Benefit Analysis

Additional Social Benefits

**Economic**
- Cyclists spend the most money at local businesses *

**Social**
- Less city pollution better for healthy lungs
- Increased local business activity

**Environment**
- Less waste than vehicle production.
- Excitement about green tech

Money Spent at Local Businesses Per Capita Per Week by Different User Types:

<table>
<thead>
<tr>
<th>User Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicyclists</td>
<td>$168</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>$158</td>
</tr>
<tr>
<td>Car drivers</td>
<td>$143</td>
</tr>
<tr>
<td>Public transit</td>
<td>$111</td>
</tr>
</tbody>
</table>

Subjects who commuted by car on a daily basis gained nearly twice as much weight over a five-year period as those who didn’t have a car-based commute.

-American Journal of Preventive Medicine
1. Carbon Footprint Calculations

<table>
<thead>
<tr>
<th>Material</th>
<th>CO₂ Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Car</td>
<td>0.383 kg CO₂/miles for 1 mile</td>
</tr>
<tr>
<td>Electric Longboard</td>
<td>0.0105 kg CO₂/miles for 13 miles</td>
</tr>
</tbody>
</table>

⇒ 2.8% car emissions

2. Material Selection

<table>
<thead>
<tr>
<th>Material</th>
<th>Environmental Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA Plastic</td>
<td>Biodegradable (made from fermented plant starch)</td>
</tr>
<tr>
<td>Carbon Fiber</td>
<td>Long lifecycle, recyclable, energy intensive to produce (more so than steel)</td>
</tr>
<tr>
<td>Maple</td>
<td>Often grown/harvested sustainably, native to U.S.</td>
</tr>
<tr>
<td>Steel</td>
<td>Production is energy intensive and emits GHG (not as much as Al and other metals), recyclable</td>
</tr>
<tr>
<td>Li-ion Battery</td>
<td>Very long life, can be recycled, contributes to resource depletion of cobalt, copper, nickel, etc</td>
</tr>
<tr>
<td>Raspberry Pi</td>
<td>Complies to EU reg. on electronic waste.</td>
</tr>
</tbody>
</table>
Business Plan

Open Source
All components can be easily purchased or 3d printed.

Free
Will always be free of charge. Encourages adoption and engagement.

Simple
No oversight needed - anyone can build, regardless of background.
1. A young, urban, innovative commuter looking for a replacement for their current commute.

2. A young, urban, commuter looking to adapt their commute with an innovative last mile solution.

An e-bike-esque commuter looking for more flexibility.
# Total Cost of Final Prototype

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plywood</td>
<td>1/2&quot; thick, 2’ x 4’ sanded plywood</td>
<td>1</td>
<td>$13</td>
</tr>
<tr>
<td>Maple Veneers</td>
<td>1/2&quot; thick (1); 10&quot;x24&quot;</td>
<td>1</td>
<td>$15</td>
</tr>
<tr>
<td>Steel Rods</td>
<td>1/4&quot;-20 Steel Rods, 10&quot; long</td>
<td>2</td>
<td>$5</td>
</tr>
<tr>
<td>Carbon Fiber Rods</td>
<td>Carbon Fiber Rod, 1/2&quot; Diameter, 12&quot; Long</td>
<td>2</td>
<td>$48</td>
</tr>
<tr>
<td>Fasteners</td>
<td>Bolts, Locknuts</td>
<td>NA</td>
<td>$10</td>
</tr>
<tr>
<td>Mechanical Kit</td>
<td>83mm wheels (2), trucks (2), 1/4&quot; truck risers, drivetrain*</td>
<td>1</td>
<td>$299</td>
</tr>
<tr>
<td>Motor</td>
<td>6355 190kV Motors, 2500W, 2.83Nm</td>
<td>1</td>
<td>$90</td>
</tr>
<tr>
<td>Battery</td>
<td>6S2P Electric Skateboard EPower Battery Pack</td>
<td>1</td>
<td>$185</td>
</tr>
<tr>
<td>VESC</td>
<td>Torque ESC VESC Electronic Speed Controller</td>
<td>1</td>
<td>$100</td>
</tr>
<tr>
<td>Remote</td>
<td>2.4 GHZ Remote Controller</td>
<td>1</td>
<td>$60</td>
</tr>
<tr>
<td>Servo Connector</td>
<td>Male-male connection, connects VESC to RC Receiver</td>
<td>1</td>
<td>$2</td>
</tr>
</tbody>
</table>

Total: $826
Further improvements:

- Mechanical
  - Lower volume & weight
- Hardware
  - Increase mile range
- Software
  - Improve app UI
  - Automatic Tracking
  - Improve Map Statistics & Features