Collapsible Electric Longboard

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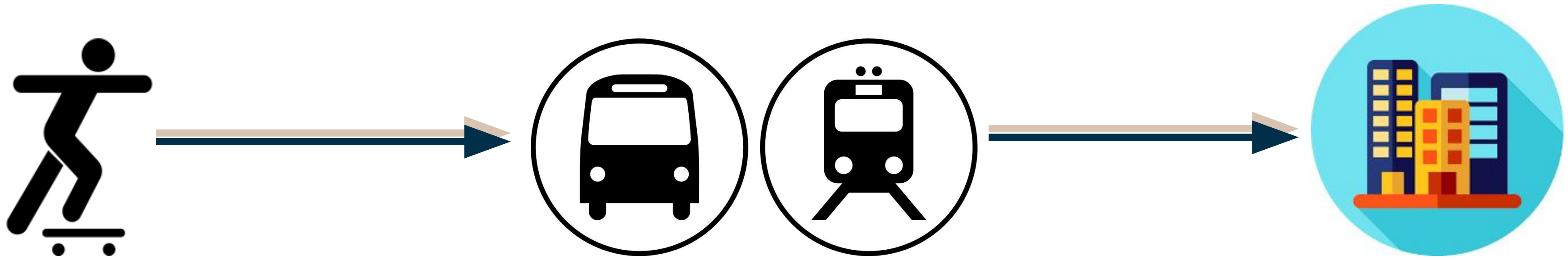
April 23, 2018

Motivation

- Exploring Alternative/Emerging Transportation
- Reducing Car Dependency

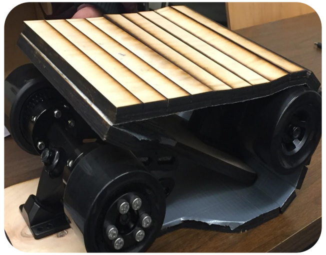


- The Last Mile Solution → Promoting multimodal transportation

Mechanical Technical Design

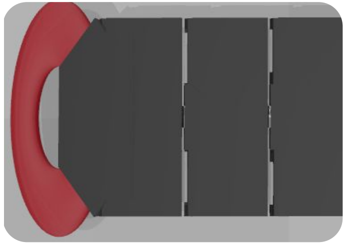
Prototype Designs

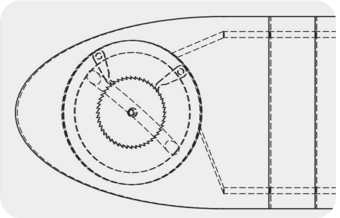
Mesh or Hinges



Self-Connecting Hinges

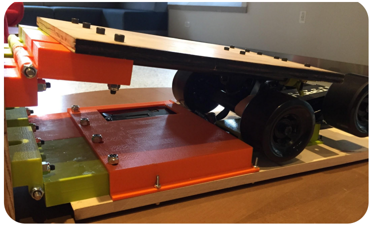
Interconnecting Beams





Ratchet Wire Deck

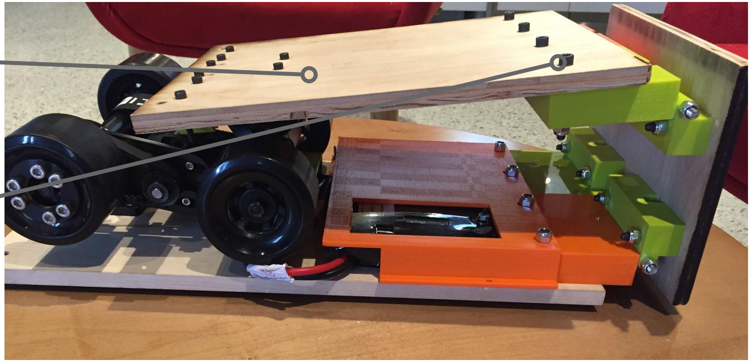
Hinges + Structural Rods



Final Prototype Design

Maple Wood & Plywood

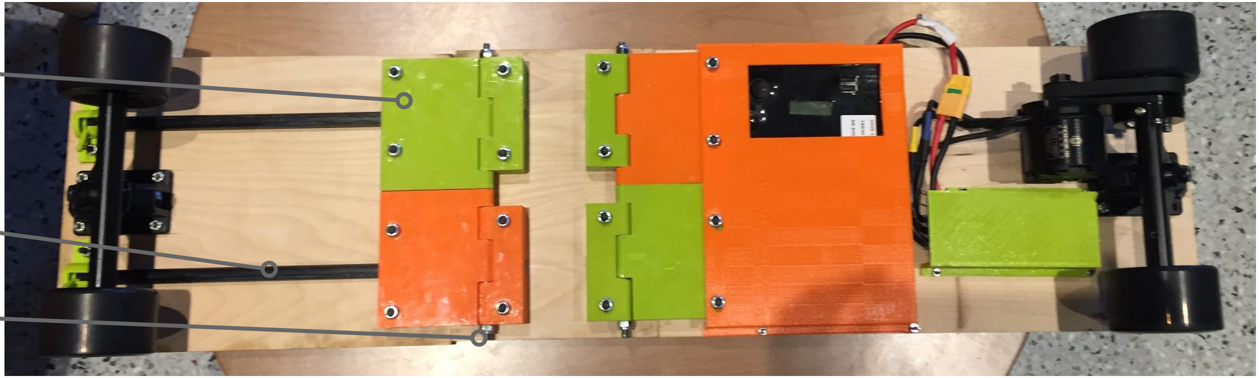
Steel Alloy



PLA Plastic Hinges, 7% Infill

Carbon Fiber

18-8 Stainless Steel



Stress Analysis

Analyses assume a weight of 250 lb.

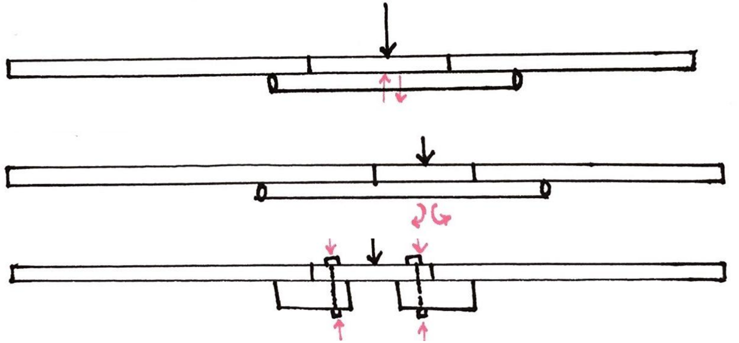
1. Shear of structural rods → Factor of Safety (FS): 46.5

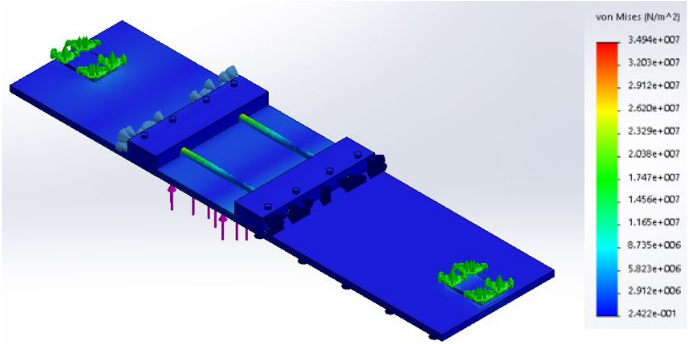
2. Bending of structural rods → FS: 8.61

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)

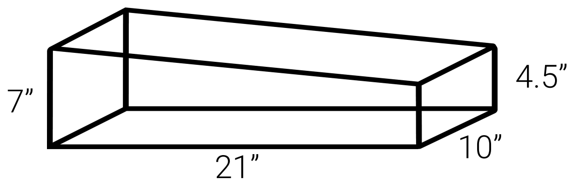




Testing

Weight of Skateboard: 20 lbs

Volume of Skateboard: $1312.5in^2$.
Folded spans 20” vs. 38.5” unfolded.



Deflection: 0.125” at rest.
1.775” with weight at center.

Top Speed: 15.2 mph

Acceleration on Flat Ground: $0.548\ m/s^2$ or 1.23 mph/s

Mile Range: 3.88 miles*

Energy Usage: 22.2 Wh/mile*

*with testing speeds of 6-11 mph

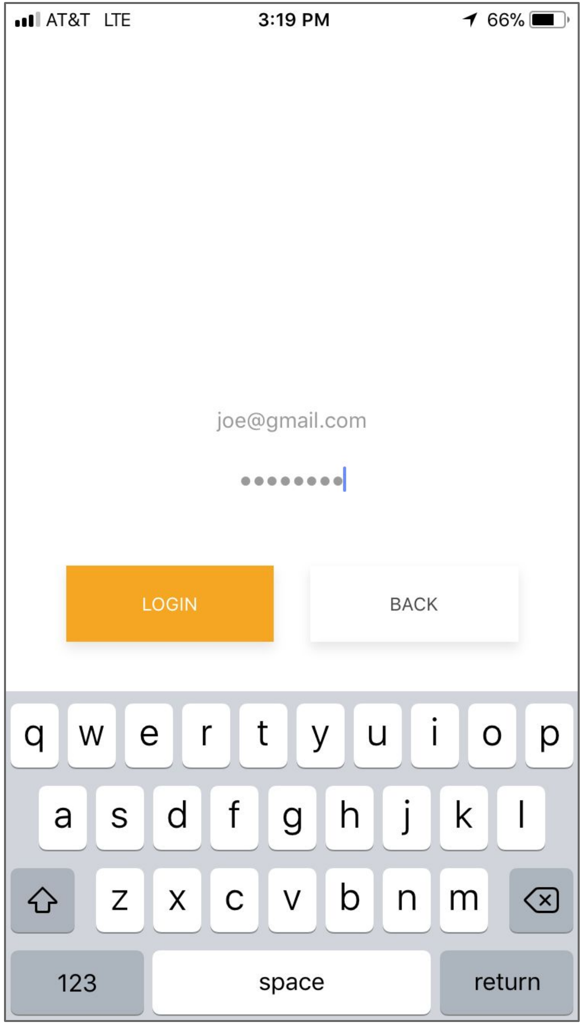
Software Technical Design

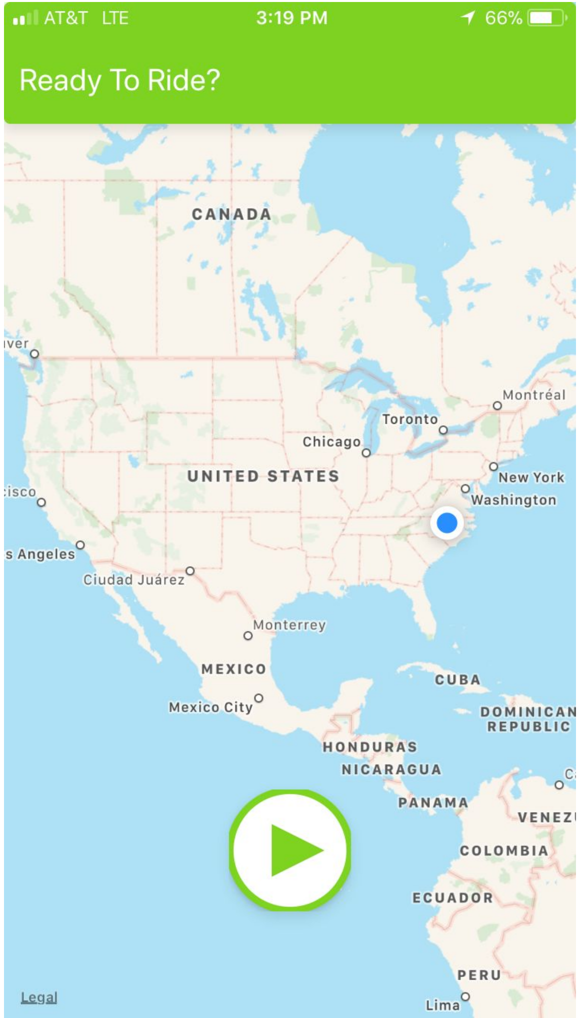
Front End (Presentation)

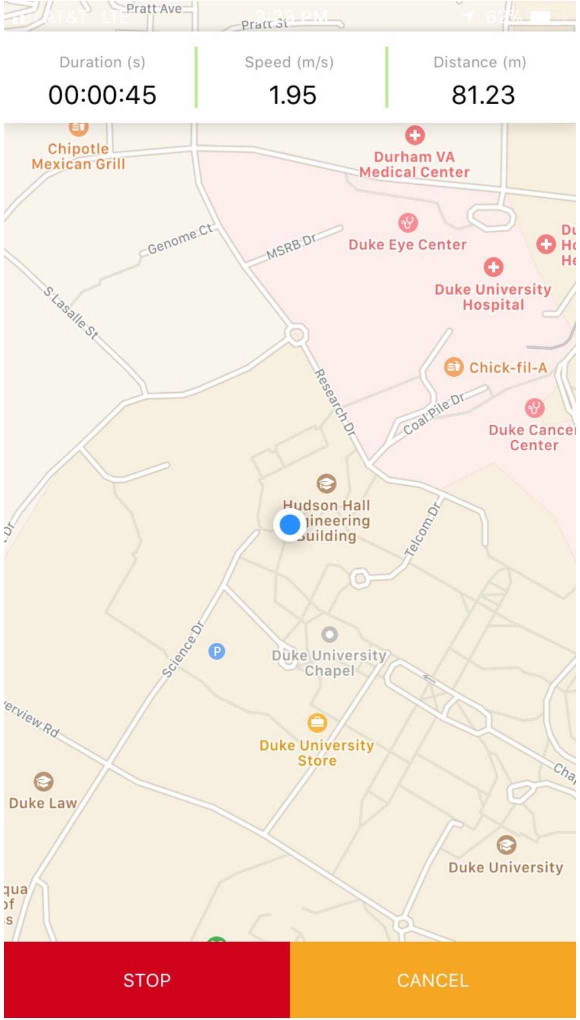
Swift, Sketch and Supernova Studio
User Interface
Screen Transitions
User Input Collection

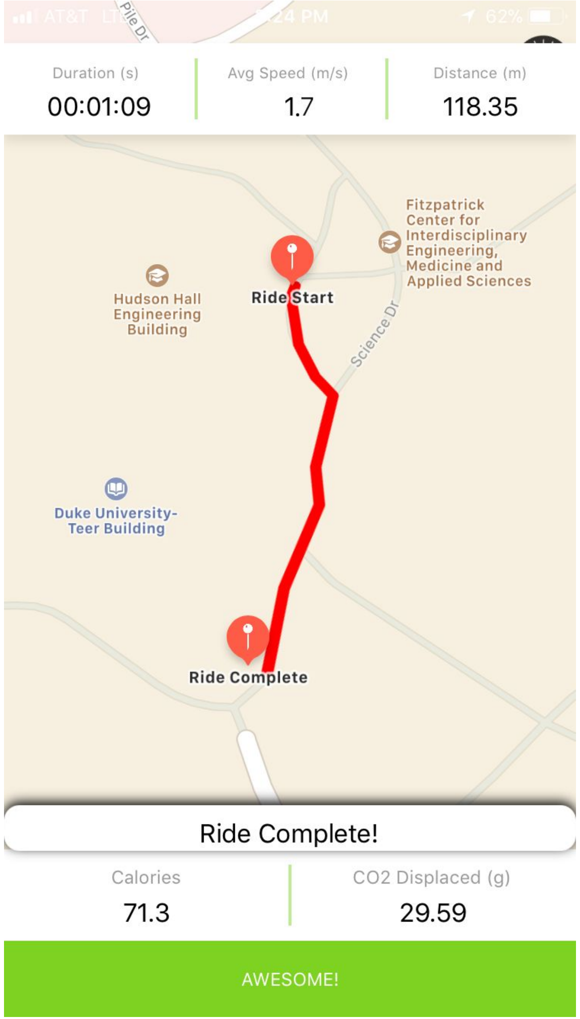
Back End (Data Access)

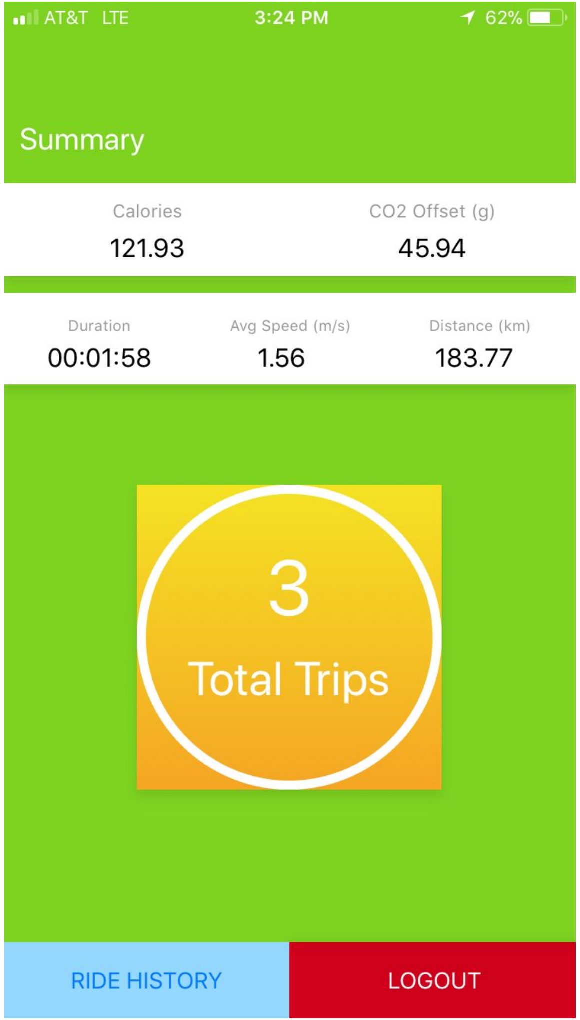
Swift and Firebase
Real-time Speed and Distance Calculations
Account Info and Trip History
Database Queries

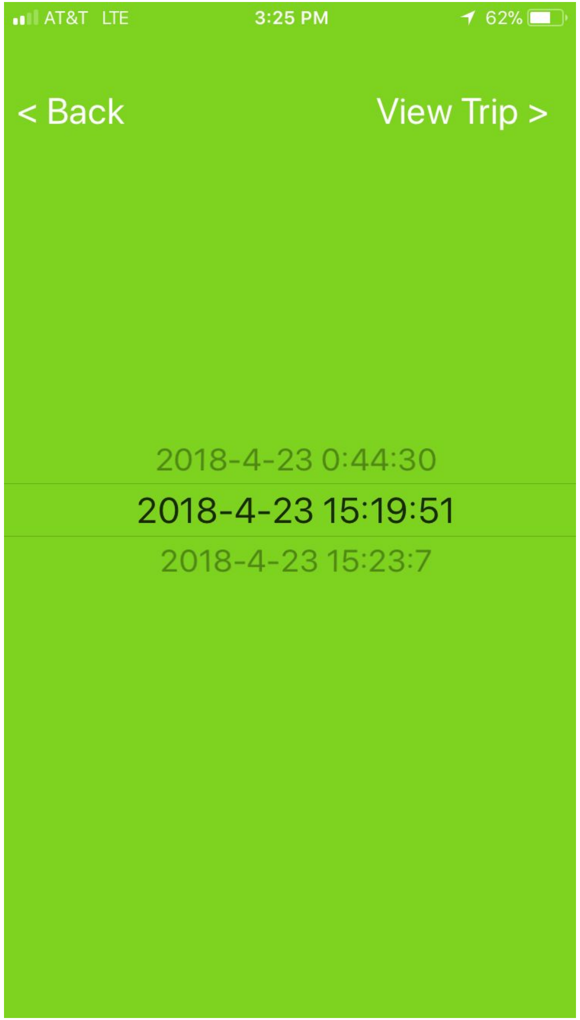

AT&T LTE
3:19 PM
66%
joe@gmail.com
LOGIN
BACK
q w e r t y u i o p
a s d f g h j k l
z x c v b n m
123
space
return


AT&T LTE
3:19 PM
66%
Ready To Ride?
CANADA
UNITED STATES
Montréal
Toronto
Chicago
New York
Washington
Ciudad Juárez
Monterrey
MEXICO
Mexico City
CUBA
DOMINICAN REPUBLIC
HONDURAS
NICARAGUA
PANAMA
COLOMBIA
ECUADOR
PERU
Lima
Legal


Duration (s)
00:00:45
Speed (m/s)
1.95
Distance (m)
81.23
Chipotle Mexican Grill
Durham VA Medical Center
Duke Eye Center
Duke University Hospital
Chick-fil-A
Genome Ct
MSRB Dr
S Lasalle St
Research Dr
Coal Pile Dr
Telcom Dr
Science Dr
Duke University Chapel
Duke University Store
Duke Law
Duke University
STOP
CANCEL


Duration (s)
00:01:09
Avg Speed (m/s)
1.7
Distance (m)
118.35
Fitzpatrick Center for Interdisciplinary Engineering, Medicine and Applied Sciences
Hudson Hall Engineering Building
Ride Start
Science Dr
Duke University-Teer Building
Ride Complete
Ride Complete!
Calories
71.3
CO2 Displaced (g)
29.59
AWESOME!


AT&T LTE
3:24 PM
62%
Summary
Calories
121.93
CO2 Offset (g)
45.94
Duration
00:01:58
Avg Speed (m/s)
1.56
Distance (km)
183.77
3
Total Trips
RIDE HISTORY
LOGOUT


AT&T LTE
3:25 PM
62%
< Back
View Trip >
2018-4-23 0:44:30
2018-4-23 15:19:51
2018-4-23 15:23:7

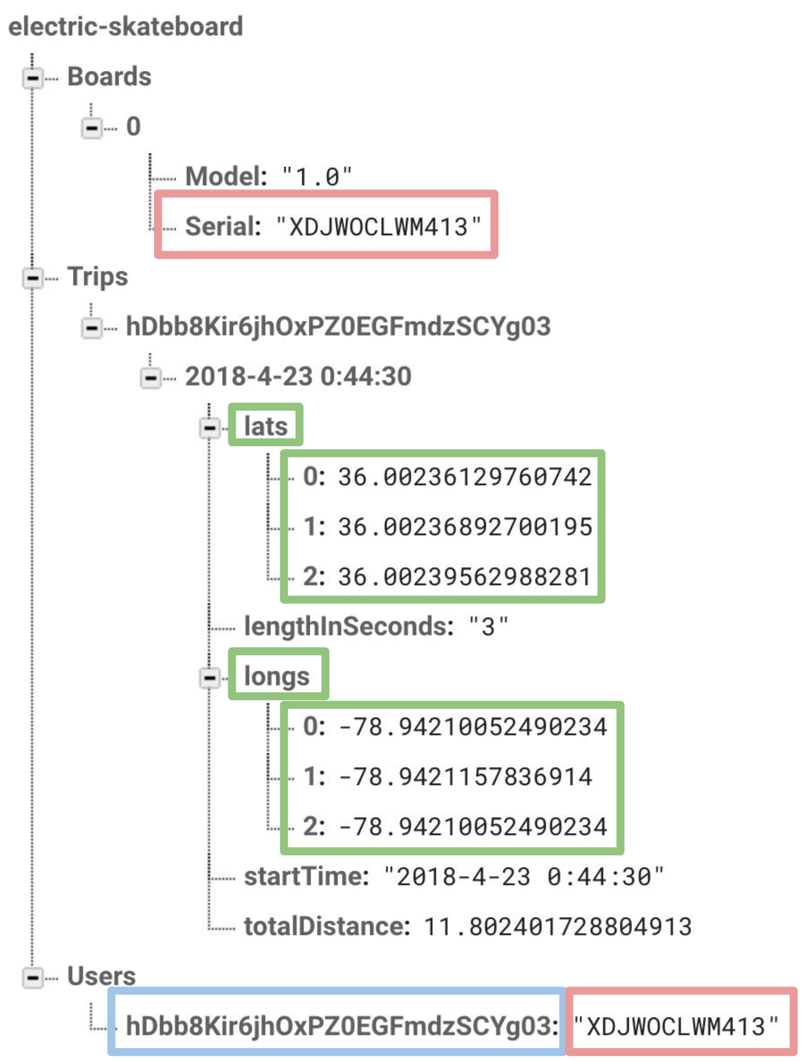
Database Design

Firebase Advantages:

JSON Database (unstructured data stored in hierarchical key-value pairs)

Built-In Authentication

Swift Application Programming Interface



Electrical Design

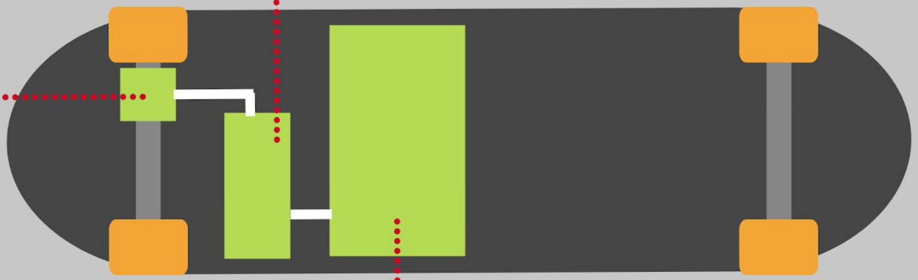
Electric Components

Motor

The motor used on this board is a 190KV brushless DC motor. This initial board uses a single-motor setup, but a dual-motor setup could be used to increase acceleration and hill-climbing ability in a production model.

ESC

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.



Battery

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.

iOS App Design

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.

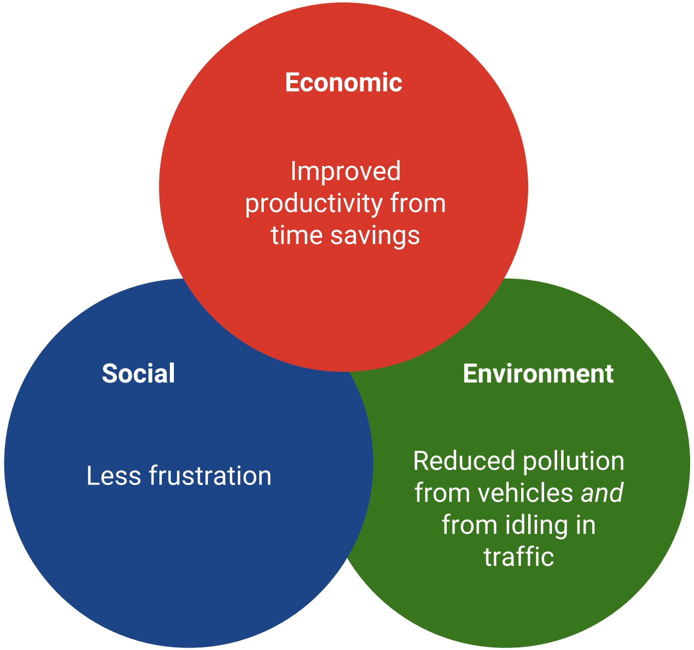
Societal Impacts

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

42 hours

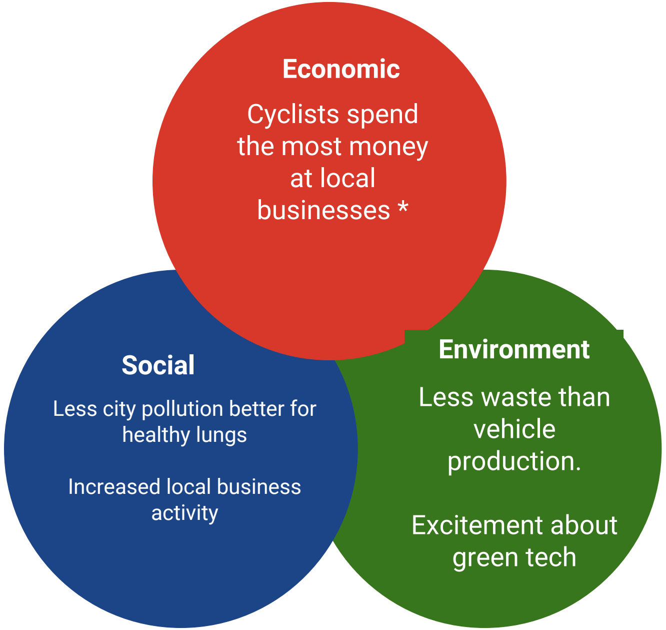
Social Benefit Analysis

Reduced Traffic Congestion



Social Benefit Analysis

Additional Social Benefits



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

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

Bicyclists	$168
Pedestrians	$158
Car drivers	$143
Public transit	$111

Environmental Benefit Analysis

1. Carbon Footprint Calculations

Gas Car

$0.383\ kg_{CO2}/miles$

$1.53\ kg_{CO2}$ for 4 miles

Electric Longboard

$0.0105\ kg_{CO2}/miles$

$0.0420\ kg_{CO2}$ for 13 miles

⇒ 2.8% car emissions

2. Material Selection

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

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.

Target Market

Geographic	*Demographic*	*Behavioral*	*Psychographic*
Urban, developed bike lane infrastructure	Age: 20-30 Able to spend ~$800	Regular commuter Status gained from different or cool	Liberated, young, early-adopter Want to have *fun* commuting, in life

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

Item	*Description*	*Quantity*	*Price*
Plywood	1/2" thick, 2' x 4' sanded plywood	1	$13
Maple Veneers	1/2" thick (1); 10"x24"	1	$15
Steel Rods	1/4"-20 Steel Rods, 10" long	2	$5
Carbon Fiber Rods	Carbon Fiber Rod, 1/2" Diameter, 12" Long	2	$48
Fasteners	Bolts, Locknuts	NA	$10
Mechanical Kit	83mm wheels (2), trucks (2), 1/4" truck risers, drivetrain*	1	$299
Motor	6355 190kV Motors, 2500W, 2.83Nm	1	$90
Battery	6S2P Electric Skateboard EPower Battery Pack	1	$185
VESC	Torque ESC VESC Electronic Speed Controller	1	$100
Remote	2.4 GHZ Remote Controller	1	$60
Servo Connector	Male-male connection, connects VESC to RC Receiver	1	$2
		Total	$826

Looking forward

Further improvements:

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

Questions?