Electric Bikes and Electric Scooters
as Alternative Commute Vehicles
-----------A Pilot at Stanford

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ETC-t: Innovative Transportation Systems

March 12, 2015
E-bikes and e-scooters as alternative commute vehicles

U.S. e-bikes and e-scooters market issues

Demand
- Smooth traffic flow
- Higher level of mobility
- Cost effectiveness
- Comfortable travel experience
- Environmental friendliness

Supply
- Technology improvement
- Maturity of products

Traffic Challenges
- Solution

Demand Estimation
- Benefits

Market forecast

Pilot implementation

A pilot at Stanford
Market Issues: Demand for Smooth Traffic Flow

High congestion cost (energy, time, environment)

Annual Congestion Cost (energy, time, environment)

- In 2011: $65 per year
- Fuel cost: $65 per automobile commuter
- Time delay: 38 hours per person
- CO2 emission: 113 million pounds

Source: Texas A&M Transportation Institute, Urban Mobility Report
http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/ums/congestion-data/national/national-table-all.pdf
Market Issues: Demand for Higher level of Mobility

E-bikes and e-scooters as alternatives to automobiles

Commute Time by Modes of Transport and Distance (minutes, one way)

<table>
<thead>
<tr>
<th>Mode of Transportation</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike</td>
<td>5 miles</td>
</tr>
<tr>
<td>Car (traffic)</td>
<td>9 miles</td>
</tr>
<tr>
<td>E-bike</td>
<td>9 miles</td>
</tr>
<tr>
<td>E-scooter</td>
<td>7 miles</td>
</tr>
</tbody>
</table>

Within 30 minutes:

Smooth traffic flow
Higher level of mobility and travel efficiency
Cost effective
Environmental friendly and energy efficient
Novel, enjoyable and comfortable experience

Note: The analysis of “Commute Time by Mode of transportation and distance” is based on 6 arbitrary trip that span a variety distance to Google campus.
Market Issues: Demand for Higher Level of Mobility

E-scooters connect travel stops---a solution to the last-mile problem

Transit station

Home

Parking lot

Destination

Smooth traffic flow

Higher level of mobility and travel efficiency

Cost effective

Environmental friendly and energy efficient

Novel, enjoyable and comfortable experience

Demand
Growing acceptance of two-wheel transportation

Market Issues: Change of Attitudes and Travel Habit

Bike Sharing Program in the U.S.

Source: The bike-sharing world map
https://www.google.com/maps/d/u/0/viewer?ll=43.580391,-42.890625&source=embed&ie=UTF8&om=1&msa=0&spn=143.80149,154.6875&z=1&hl=en&mid=zGPlSU9zZvZw.kmqv_ul1MfkI
Market Issues: Demand for Cost Effective Transportation

Compare to automobiles: Lower capital and maintenance cost

<table>
<thead>
<tr>
<th></th>
<th>Automobile</th>
<th>E-bike</th>
<th>E-scooter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital cost</strong></td>
<td>$6,840</td>
<td>$917</td>
<td>$330</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td>$906</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Maintenance and Repair</strong></td>
<td>$390</td>
<td>$100</td>
<td>$50</td>
</tr>
<tr>
<td><strong>Fuel cost</strong></td>
<td>$220</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Parking cost</strong></td>
<td>little</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Air pollution cost</strong></td>
<td>a lot</td>
<td>little</td>
<td>little</td>
</tr>
<tr>
<td><strong>Health benefit</strong></td>
<td>little</td>
<td>a lot</td>
<td>a lot</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td>$8,356</td>
<td>$1,017</td>
<td>$380</td>
</tr>
</tbody>
</table>

Market Issues: Demand for Cost Effective Transportation

Compare to bikes: will become cost competitive due to technology improvement

Supply

- Increasing quality and affordability of Li-ion batteries and electric motors
- Improvements on product quality and variety

Demand

- Smooth traffic flow
- Higher level of mobility and travel efficiency
- Cost effective
- Environmental friendly and energy efficient
- Novel, enjoyable and comfortable experience

Source of pictures:
http://www.faradaybikes.com/
Market Issues: Novel and Comfortable Travel Experience

Maturity of products ↔ Comfortable and novel travel experience

Supply
- Increasing quality and affordability of Li-ion batteries and electric motors
- Improvements on product quality and variety

Demand
- Smooth traffic flow
- Higher level of mobility and travel efficiency
- Cost effective
- Novel, enjoyable and comfortable experience
- Environmental friendly and energy efficient

Source of pictures: http://www.faradaybikes.com/
http://ecorecoscooter.com/
U.S. E-bikes and E-scooters Market Issues

Forces shape and expand the e-bike and e-scooter market

**Supply**
- Increasing quality and affordability of Li-ion batteries and electric motors
- Improvements on product quality and variety

**Demand**
- Smooth traffic flow
- Higher level of mobility and travel efficiency
- Cost effective
- Novel, enjoyable and comfortable experience
- Environmental friendly and energy efficient

**Governments**

**Manufacturers**

**Designers/Developers**

**Insurance companies**

**Individuals**

**Institutes**
U.S. E-bikes and E-scooters Market Issues

E-bike and e-scooter market forecast

Key players in electric vehicle manufacturing
- Toyota
- Ford
- Chevrolet
- Honda
- Nissan

Supply
- Increasing quality and affordability of Li-ion batteries and electric motors
- Improvements on product quality and variety

Demand
- Smooth traffic flow
- Higher level of mobility and travel efficiency
- Cost effective
- Novel, enjoyable and comfortable experience
- Environmental friendly and energy efficient

Increasing commute demand

Source: Navigant Research Electric Vehicle Consumer Survey
U.S. E-bikes and E-scooters Market Issues

E-bike and e-scooter market forecast

<table>
<thead>
<tr>
<th>Electric Vehicles</th>
<th>2015 sales volume</th>
<th>2024 sales volume</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-bikes</td>
<td>172,516</td>
<td>286,000</td>
<td>6.8%</td>
</tr>
<tr>
<td>E-scooters</td>
<td>4,934</td>
<td>21,756</td>
<td>17.9%</td>
</tr>
</tbody>
</table>

Source: Navigant Research Electric Vehicle Consumer Survey
A Practical Case at Stanford
Traffic Challenges at Stanford

Why people drive so much?

### Top four reasons for driving alone at Stanford

- Irregular work schedule
- No reasonable transit options
- Anything else takes too much time
- Don’t like to depend on others

### Assumption:

1. Bicycles can not meet all demand due to time consumption, physical exertion, bike thefts, and dressing code

2. Time flexibility is valued which can not be satisfied by public transit

### Percentage of biking and driving alone among Stanford students and employees

- **Within 2 miles:**
  - 55% bike to school
  - 20% drive to school
- **Within 4 miles:**
  - 44% bike to school
  - 30% drive to school

**Commute distance (miles)**

- **Percentage of driving alone**
- **Percentage of biking**

Source: 2014 Stanford Commute Survey
## Our Solution

**E-bikes and e-scooters as alternative commute vehicles**

- Reduce commute time
- Provide flexibility and convenience
- E-scooters solve the last mile problem

### Goal of the program

<table>
<thead>
<tr>
<th>Reduce the number of cars crossing campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide Stanford commuters transit alternatives</td>
</tr>
<tr>
<td>Evaluate commuters’ enthusiasm for the alternative modes of transport</td>
</tr>
<tr>
<td>Generate long-term benefit to university and commuters</td>
</tr>
</tbody>
</table>

### Methods

<table>
<thead>
<tr>
<th>Build travel diary dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect User experience on e-bikers and e-scooters</td>
</tr>
<tr>
<td>Compare commute patterns before and after the pilot, to observe changes in commute patterns</td>
</tr>
</tbody>
</table>

Source: 2014 Stanford Commute Survey
Demand Estimation
How many people can be potentially moved out of the cars?
Where are they?

2528 people commute from:
- Menlo park
- Palo Alto
- Atherton
- Redwood City
- Los Altos
- Portola Valley
- Mountain View
- San Carlos

Limit access to the original map at:
http://stanf.maps.arcgis.com/apps/presentation/index.html?webmap=4cf9a720d5664545ac2fbfddb8994657&slide=1
# Benefits

## Benefits to Universities

<table>
<thead>
<tr>
<th>Benefits to Universities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Better on-campus transportation (less cars crossing campus)</td>
<td></td>
</tr>
<tr>
<td>Low maintenance cost</td>
<td></td>
</tr>
<tr>
<td>Save parking space (cars, e-scooters)</td>
<td></td>
</tr>
<tr>
<td>Environmental friendly</td>
<td></td>
</tr>
</tbody>
</table>

## Motivations for Commuters

<table>
<thead>
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<th>Motivations for Commuters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase commute distance and reduce commute time</td>
<td></td>
</tr>
<tr>
<td>Little physical exertion</td>
<td></td>
</tr>
<tr>
<td>Solve the last mile problem, more transport options (for e-scooters)</td>
<td></td>
</tr>
<tr>
<td>Don’t worry about theft (for e-scooters)</td>
<td></td>
</tr>
</tbody>
</table>


Pilot Implementation
Scope and timeline

<table>
<thead>
<tr>
<th>Source partners</th>
<th>Organize volunteers</th>
<th>Launch pilots</th>
<th>Collect feedback</th>
<th>Full scale implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source partners and procure 15 e-scooters and 20 e-bikes</td>
<td>Organize 35 volunteers</td>
<td>Assign GPS trackers to volunteers (before pilot control week)</td>
<td>Assign e-scooters to 15 volunteers (Group A)</td>
<td>Assign GPS trackers to volunteers (after pilot control week)</td>
</tr>
<tr>
<td>Get approvals from relevant departments</td>
<td>Organize safety training</td>
<td>Assign e-bikes to 20 volunteers (Group B)</td>
<td>Swap group A and B</td>
<td>Collect feedback and analysis</td>
</tr>
</tbody>
</table>

Collect data through GPS trackers
Collect daily travel information through surveys
Collect user experience through exit interviews
Future Work

Design business models of e-bikes/e-scooters programs at Stanford
- School owned, e-bike/e-scooter sharing program
- School owned, leasing by quarter/year program
- Privately owned, school subsidized program

Search for partners and opportunities to scale up e-bike and e-scooter program
Acknowledgements

Advisors and partners:

- Stefan Heck, Frederick Soo, Brendan Pierpont, Regina Clewlow
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- Land, Buildings & Real Estate at Stanford University
- Precourt Institute for Energy at Stanford University
- EcoReco Scooters
- Faraday Bicycles