Reinventing the Automobile:
Personal Urban Mobility for the 21st Century
Massachusetts Institute of Technology (MIT) Media Lab

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2011 MIT Europe Conference Innovation in a Networked World: Technology, People, and Places
In Memory of William J. Mitchell (1944-2010)
Professor of Architecture and Media Arts and Sciences (MIT)

Reinventing the Automobile
Personal Urban Mobility for the 21st Century

William J. Mitchell, Christopher E. Borroni-Bird, and Lawrence D. Burns
1. **50% of Global Population** – Currently live in dense urban areas (red line)

2. **Increased Urban Densification** – Urbanization trend will continue for the foreseeable future (rural populations will flatten and decrease)

3. **Increased Inefficient Energy Use** – Leading to increased carbon emissions and climate change

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In the 21st century about 90% of population growth will be in urban areas; these will account for 60% of the population and 80% of the wealth. Hence, the pattern of future energy demand will increasingly be determined by urban networks.

Transportation and building operations typically account for at least 60% of urban energy use.

In congested urban areas, about 40% of total gasoline use is in cars looking for parking.

*Imperial College Urban Energy Systems Project*
Congestion and Pollution (Taiwan Case)

5.7 million cars
13.56 million motorcycles/scooters.
3.5% of the growth

11 percent of the air pollution is caused by scooters.

2 person per scooter (average)
4 person per car (average)
6.3 car per parking space
9.8 scooters per parking space

33% cars
33% scooters
10% taxi
24% mass transit
1. **Private Automobiles** – Major source of pollution and carbon emissions; massive congestion, parking, and noise problems

2. **Public Transportation** – Does not cover the entire city; inconvenient and inflexible schedules

3. **First Mile-Last Mile Problem** – Of public transit is not solved
Restrictions to Private Car Ownership

1. **License Plate Lottery** – Beijing has restricted number of licenses to 240,000 for new cars (2011)

2. **Taxation and other limits** – Certificate of Entitlement (COE) and Additional Registration Fee (ARF) of Singapore designed to limit the total number of cars through a bidding system and taxation (140% in addition to cost of vehicle)

3. **Congestion Pricing** – London, Singapore, Stockholm, Milan

4. **License Plate Rationing** – Restricts driving based on license plate number (Mexico City, Bogotá, São Paulo, Auckland, Athens, and Santiago)
The Emergence of Vehicle Sharing

1. Bicycle Sharing is exploding: By 2008 more than 80 cities around the world will offer the service. Paris’s Vélib bike sharing system utilizes over 30,000 bikes at 1400 stations.

2. Car Sharing systems like ZipCar, Car2go (by Daimler-Benz), and Autolib (car version of Vélib) are rapidly expanding.

3. 5000 cars in the US, 10% adoption rates in cities, over 600 cities in the world have it.

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**Mobility-on-Demand Systems**

**A Lightweight Electric Vehicle Ecosystem**

New Use Model

Users are allowed to pick up electric vehicles from any charging station and drive to any other charging station in a one-way sharing scheme (point-to-point rental)

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In-Wheel Electric Motor Technology (Wheel Robots)

1. Integrated in-Wheel Motor Module – Contains electric drive motors, electric steering, braking, suspension in one self-contained unit.

2. Utilization of by-wire controls – Electronic control of Wheel Robot provides design flexibility with vehicle architecture and programmability of vehicle control system.

3. Lightweight Manufacture and Servicing – Economies of Scale at Wheel assembly level and easy maintenance and replacement.

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CityCar Video
CityCar Video
Access and Maneuverability

Front Entry and Exit
Users can easily enter and exit directly onto the street curb with the CityCar's nose-into-the-curb parking
Energy and Space Efficient

CityCar Target Specifications (Unfolded)
Length: 2500mm
Width: 1700mm
Weight: 450kg
Range: 100km
CityCar Parking Ratios: 3 to 1 vs. Traditional Vehicles

Folded CityCar vs. conventional 4-door sedan
Parking ratio = 3.3 : 1
CityCar Half-Scale Prototype
CityCar Video
CityCar Half-Scale Prototype
CityCar Video
CityCar Study in Hong Kong
CityCar Study in Hong Kong

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CityCar Study in Singapore

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CityCar Study in Singapore
CityCar Study in Singapore

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CityCar Study in Bilbao, Spain
Contactless Inductive Charging (Wireless Power Transfer)
The CityCar Full-Scale Ergonomics Study

Please refer to live presentation
A collaboration with: Sanyang (SYM) and Industrial Technology Research Institute (ITRI) of Taiwan

The RoboScooter
Folding Electric Motor Scooter

The GreenWheel
Smart Electric Bicycle

300W Electric Motor
Planetary Gearbox
Lithium Nanophosphate Cells (by A123 Systems)
RoboScooter Video
GreenWheel Video
Renewable Power, Energy Storage, and Smart Grids

With large-scale use, car stacks throw enormous battery capacity into the electrical grid.

Effective utilization of inexpensive, off-peak power and clean but intermittent power sources – solar, wind, wave, etc.

A smart, distributed power generation system composed of these sources (the entire city as a virtual power plant) minimizes transmission losses.
Developing Electric Charging Infrastructure

Integrate transformers into nearby buildings or use existing building electrical infrastructure
Battery Performance

Lithium-ion battery cells based on nano-phosphate electrode technology to provide low impedance, energy dense batteries that can be rapidly recharged with extended cycle life.
### Vehicle Charge Times by Power Source

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Pack Size (kWh)</th>
<th>120V, 15 A: 1.8 kW (≈ 2 x 🚗)</th>
<th>220V, 50 A: 11 kW (≈ 11 x 🚗)</th>
<th>220V, 200 A: 44 kW (≈ 44 x 🚗)</th>
<th>480V, 400 A: 330 kW* (≈ 330 x 🚗)</th>
<th>480V, 1000 A: 830 kW* (≈ 830 x 🚗)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GreenWheel</td>
<td>0.2</td>
<td>7 min</td>
<td>1 min</td>
<td>&lt; 1 min</td>
<td>&lt; 1 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>RoboScooter</td>
<td>0.5</td>
<td>17 min</td>
<td>3 min</td>
<td>&lt; 1 min</td>
<td>&lt; 1 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>Motorcycle (60 mi)</td>
<td>5</td>
<td>3 hours</td>
<td>27 min</td>
<td>7 min</td>
<td>&lt; 1 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>CityCar</td>
<td>10</td>
<td>6 hours</td>
<td>55 min</td>
<td>14 min</td>
<td>2 min</td>
<td>&lt; 1 min</td>
</tr>
<tr>
<td>Sedan (100 mi)</td>
<td>30</td>
<td>17 hours</td>
<td>3 hours</td>
<td>41 min</td>
<td>6 min</td>
<td>3 min</td>
</tr>
<tr>
<td>Taxi (180 mi)</td>
<td>60</td>
<td>34 hours</td>
<td>6 hours</td>
<td>2 hours</td>
<td>11 min</td>
<td>5 min</td>
</tr>
<tr>
<td>Public Shuttle Bus</td>
<td>150</td>
<td>84 hours</td>
<td>14 hours</td>
<td>3 hours</td>
<td>27 min</td>
<td>11 min</td>
</tr>
</tbody>
</table>

*3-phase power: Power = \sqrt{3} \times \text{Current} \times \text{Voltage}*

*Times calculated using ideal calculations given 100% power transfer*
Mobility-on-Demand IT Network

CityCar or RoboScooter (GPS enabled)

Network Link

Network Link

Scooter Station A (Rack & Kiosk)

Mobility-on-Demand Network management engine

CityCar or RoboScooter Station (Rack & Kiosk)

Network Link

Personal Electronic Devices

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Dynamic Pricing
Dynamic Pricing
Dynamic Pricing

High demand + low vehicle stock = low drop-off price

High demand + low vehicle stock = high pickup price

Low demand + high vehicle stock = high drop-off price

Low demand + high vehicle stock = low pickup price

Trip origin

Trip destination

Cheapest trip choice
Dynamic Incentives

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Dynamic Incentives

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Autonomous Parking + Folding
(in 50 unit urban housing project, 1 car/unit, $29,000 savings per car)

270 sq ft per car @ $150/ sq ft = $40,500 per car
X 50 cars = $2,025,000 for parking structure

77 sq ft per car @ $150/ sq ft = $11,550 per car
X 50 cars = $577,500 for parking structure
Urban Model

City Car Stacks in Congestion Pricing Zones (London)
Stacks placed at Underground Subway stations

- 5 minute Walking Radius (1/2 Mile Diameter)
- Non-Subway City Car Stack provide complete coverage
Complementarity with High Speed Rail
Taipei City
Implementation Study for Mobility-on-Demand System

Within 3 minutes car or scooter driving distance from MRT stations, 95% of the urbanized areas are covered. That means any place inside Greater Taipei Area can be reached within 3 minutes from MRT stations. With the density of schools and convenient stores and MRT stations in greater Taipei area, LEV network can be a one-way rental system and can be easily accessed from every corner of the city. LEV system will not only serve as a transportation system, but also will be a urban catalyst for its ultra-convenience.
Boston, USA
Implementation study for electrical charging network
Florence, Italy
Mobility-on-Demand System Implementation Study
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MIT Professional Education Program – Short Program
Innovations in Sustainable Urban Mobility [PI.966]

4-day Course Held at MIT from June 27-30th
Kent Larson (co-instructor)
Continuing Educational Units (CEUs): 2.4

http://web.mit.edu/professional/short-programs/
“It’s important to get the technology and the policy right, but in the end, the way you break a logjam is by engaging people’s imagination, people’s desire, by creating things that they never thought of before.”

-- William J. Mitchell