Challenges to a Sustainable Auto Industry

• Energy
• Environment
• Safety
• Affordability
Megatrends: Urbanization and Aging

Source: UN Population Division
Challenges to a Sustainable Auto Industry

- Energy
- Environment
- Safety
- Accessibility

Urban Mobility

- Congestion
- Parking
## Megacities – Regional Transportation Policies

<table>
<thead>
<tr>
<th></th>
<th>Delhi</th>
<th>Mumbai</th>
<th>Beijing</th>
<th>Shanghai</th>
<th>Moscow</th>
<th>Seoul</th>
<th>New York</th>
<th>London</th>
<th>Tokyo</th>
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<tr>
<td><strong>Bus Rapid Transit Lanes</strong></td>
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<td>1 week Day Ban</td>
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<td>1 Week Day Ban*</td>
<td><img src="cross.png" alt="Cross" /></td>
<td><img src="cross.png" alt="Cross" /></td>
<td>Future</td>
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<td><strong>Energy and Environmental Standards</strong></td>
<td>Euro 4</td>
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<td>Euro 4</td>
<td>Euro 4</td>
<td>Euro 3 Euro 4 by 2012</td>
<td>Euro 4</td>
<td><img src="cross.png" alt="Cross" /></td>
<td>CAFE 27.8mpg by 2011</td>
<td>Euro 4 Euro 5 by 2011</td>
</tr>
</tbody>
</table>

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Not planned ✗ Existing currently ✓ * Voluntary no road usage incentive

Source: Frost and Sullivan
What type of “car” does the city need?

City Objectives

- Reduced parking space requirements
- Safety for all road users
- Faster, more predictable travel times
- Renewable energy sources
- No pollution (air, noise)
- Accessibility for All
- Beautiful Urban Design
- Renewable energy sources
- Safety for all road users
- Faster, more predictable travel times
- Reduced parking space requirements
- Accessibility for All
- Beautiful Urban Design

Electrification, Connectivity and Appropriate Design

Future “Car”

- INFORMATION: Vehicles wirelessly communicate with each other, the road, electronic devices (pedestrians, cyclists,..)
- POWER/ENERGY: Battery and/or Hydrogen Fuel Cell, Wheel Motors, 360° electronic cocoon,…
- TRANSPORTATION: Compact and/or reconfigurable footprint and shape, based on environmental conditions

Future City

- INFORMATION: Wireless communications with infrastructure (road, intersections, parking lots, mass transit stations,…)
- POWER/ENERGY: Rapid Charging stations, Smart Grids, Inductive Charging, Electric Guideways
- TRANSPORTATION: No city center signage, dedicated lanes/zones/highways, Intelligent Intersections
Same DNA for 100 years
New Automotive DNA

**CURRENT DNA**

- Energized by Petroleum
- Powered Mechanically by Internal Combustion Engine
- Controlled Mechanically
- Stand-alone
- Total Dependence on the Driver
- Vehicle Sized for Maximum Use – People and Cargo

**NEW DNA**

- Energized by Electricity and Hydrogen
- Powered Electrically by Electric Motors
- Controlled Electronically
- “Connected”
- Semi/Full Autonomous Driving
- Vehicle Tailored to Specific Use
## EN-V (Electric Networked Vehicle): A comparison with a conventional city car

<table>
<thead>
<tr>
<th></th>
<th>Typical city car</th>
<th>Typical EN-V</th>
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</thead>
<tbody>
<tr>
<td>Mass (kg)</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>Occupancy (# seats)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Footprint (m²)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Maximum speed (km/h)</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>Propulsion output (kW)</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Driving range (km)</td>
<td>500</td>
<td>50</td>
</tr>
<tr>
<td>Vehicle energy consumption (Wh/km)</td>
<td>400</td>
<td>80</td>
</tr>
<tr>
<td>Well-to-wheels CO₂ (g /km), US electricity mix</td>
<td>150</td>
<td>50</td>
</tr>
</tbody>
</table>
EN-V: Components & Features

GPS (Global Positioning System) determines location and supports autonomous driving.

DSRC ANTENNA (Dedicated Short Range Communication) ensures connectivity to communicate with other EN-Vs.

The CONTROLLER acts as the steering wheel, brake and accelerator pedals.

Air-cooled lithium-ion phosphate BATTERY for 25-mile city range.

FORWARD VISION SENSOR for object and collision detection.

2 brushless DC (Direct Current) ELECTRIC MOTORS 1 per wheel.

To achieve balance, the chassis slides back and forth on a SLIDE MECHANISM.

TWO WHEELS 2 wheels drive, brake and steer the vehicle.

FORWARD RANGE SENSOR for slow speed object and collision detection.
EN-V Program Next Steps:
EN-V2.0 pilot in Tianjin Eco-City
Personal Mobility & Public Transport Integration

Now

Future?

Source: MIT

Source: Rinspeed
Dynamic Pricing for Mobility-on-Demand

Source: “Reinventing the Automobile: Personal Urban Mobility for the 21st Century”
Inductive Charging Infrastructure

Static

Dynamic

Source: "Reinventing the Automobile: Personal Urban Mobility for the 21st Century"
Reinventing Urban Mobility

**Design**
Ultra-small vehicle is easy to maneuver and park and is inherently affordable and clean.

Small vehicle is easy to park at public transport stations or to dock on larger transport vehicle, encouraging more use of public transport.

**Electrification**
Battery propulsion provides zero emissions & encourages diverse, renewable energy sources.

EVs can be charged at key locations, such as public transport stations and parking lots.

**Connectivity**
Wireless communications helps to avoid collisions and optimize throughput.

Wireless communications can co-ordinate with public transport or can help to locate nearest vehicle.
Summary

- Automobile usage in cities is common because it has some valued advantages over walking/cycling and over public transport.

- For urban use, today’s automobile is over-engineered AND under-used.

- By reinventing the automobile and the ownership model, it is possible to preserve its benefits while significantly reducing the side-effects in urban use.

- Autonomy can enhance the mobility experience and enable personal mobility for all the population.

- These same enablers (electrification, connectivity and vehicle design) can also create new opportunities for seamlessly integrating personal and public transport.

- Autonomy can enhance the consumer experience and improve the business model for mobility-on-demand systems.