Reinventing the Automobile

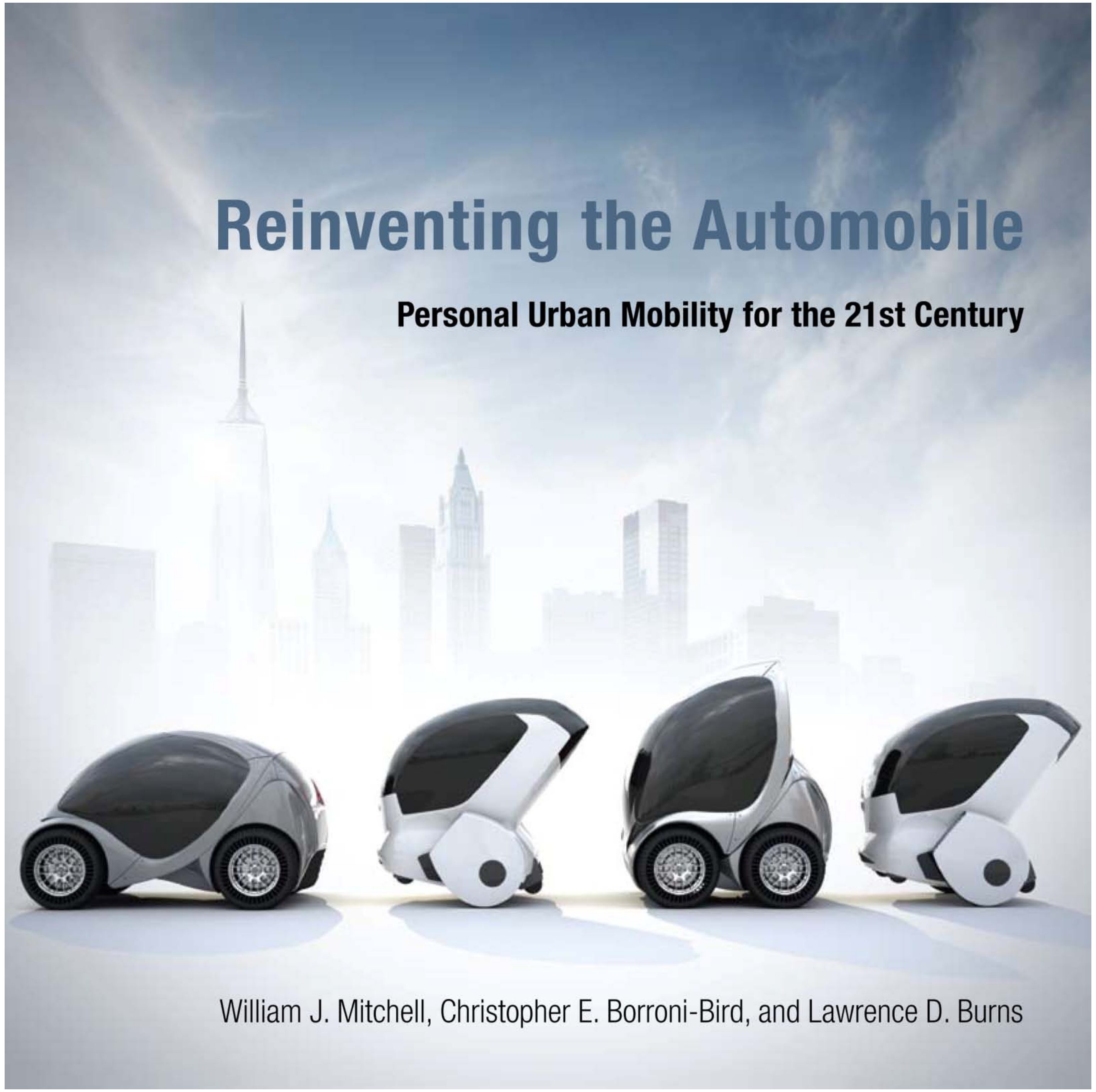
Personal Urban Mobility for the 21st Century

Ryan Chin, MIT Media Lab, Smart Cities group

The Future of Transportation
MIT *Em*Tech @ MIT *2010*

In Memory of William J. Mitchell (1944-2010)

Professor of Architecture and Media Arts and Sciences



Big Problem: Buildings and Transportation

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)

6.3car per parking space

9.8 scooters per parking space

33% cars

33%scooters

10%taxi

24% mass transit

Current Problems in Cities

Congestion, Carbon Emissions, Poor Land-Use

1. **Private Automobiles** – Major source of pollution and carbon emissions; massive congestion, parking, and noise problems

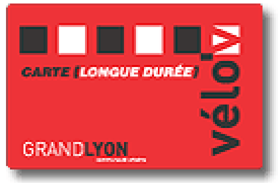
2. **Public Transportation** – Does not cover the entire city; inconvenient and inflexible schedules

3. **First Mile-Last Mile Problem**

The Emergence of Vehicle Sharing

zipcar®
wheels when you want them

Velib'
MAIRIE DE PARIS



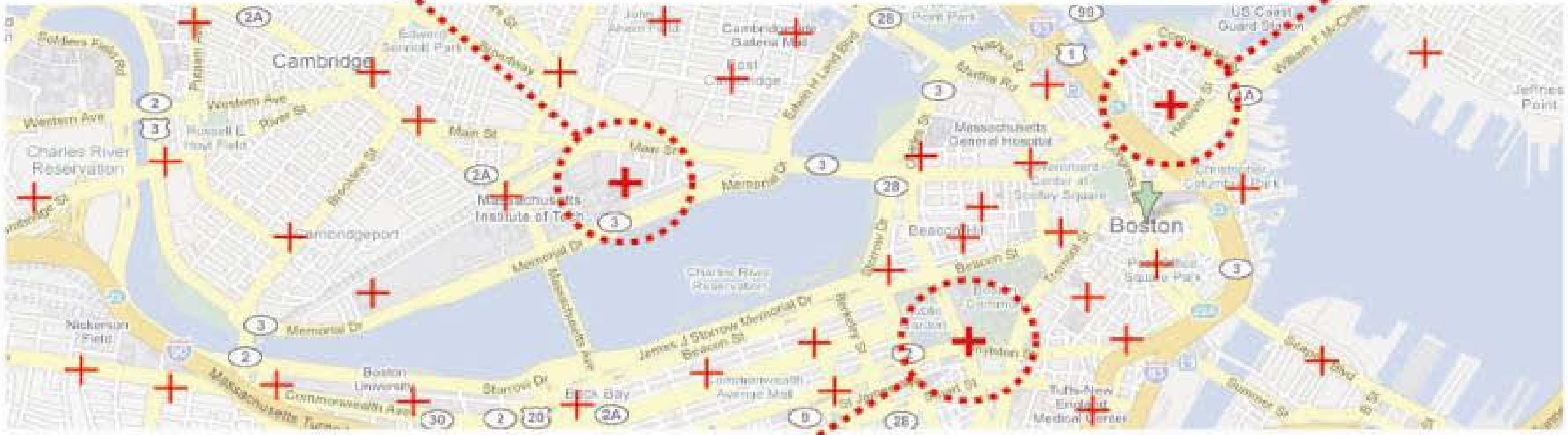
1. Bicycle Sharing is exploding: By 2008 more than 80 cities around the world will offer the service. In Paris, 30,000 bicycles are rented daily.
2. Car Sharing systems like ZipCar are rapidly expanding.
3. 5000 cars in the US, 10% adoption rates in cities, over 600 cities in the world have it.

Mobility-on-Demand Systems

A Lightweight Electric Vehicle Ecosystem

RoboScooter

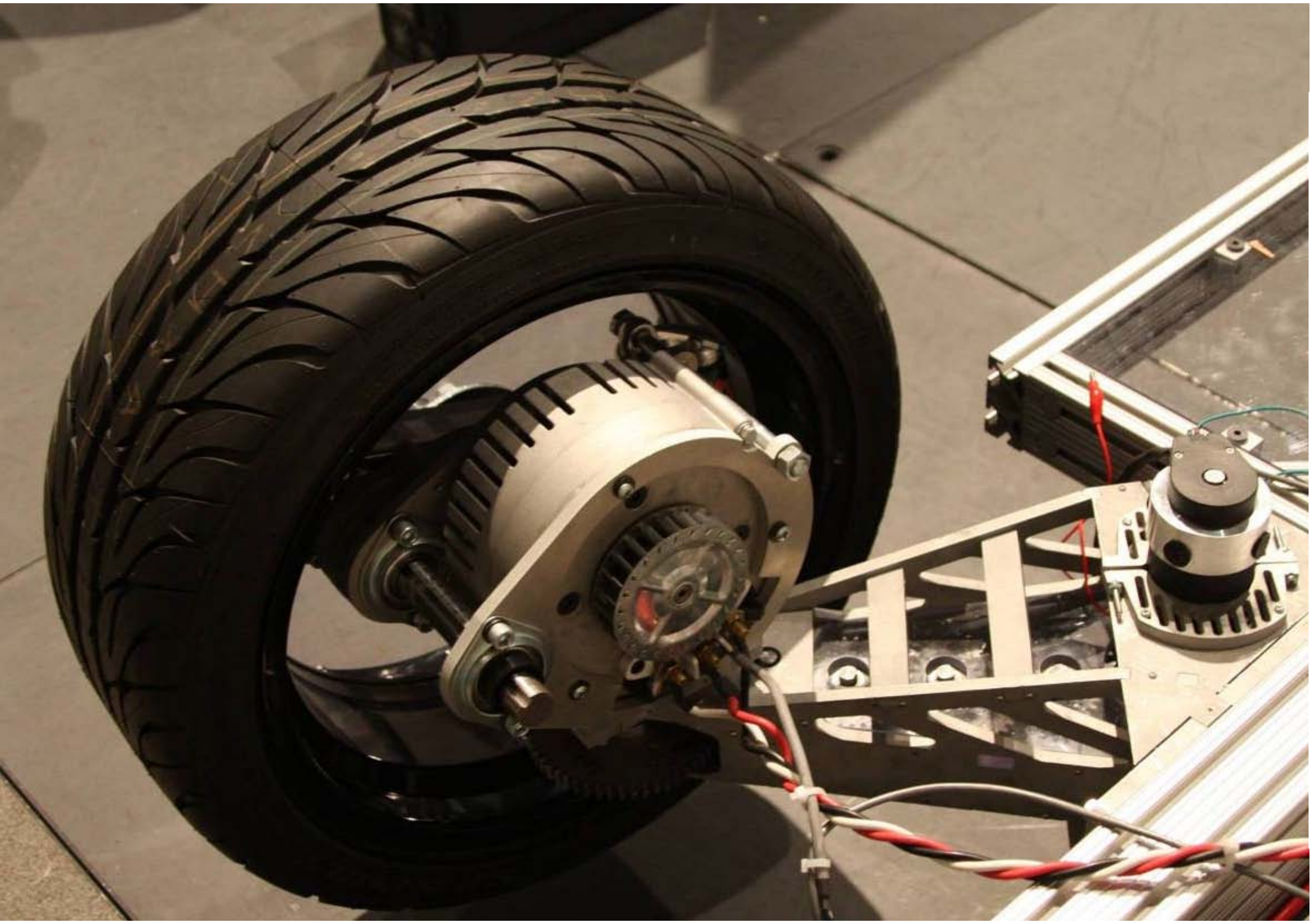
GreenWheel



CityCar

Lightweight Electric Vehicles | Design and Enabling Technologies

In-Wheel Electric Motor Technology (Wheel Robots)



The RoboScooter Folding Electric Motor Scooter

A collaboration with:
Sanyang (SYM) and
Industrial Technology
Research Institute
(ITRI) of Taiwan

RoboScooter Video

The GreenWheel Smart Bicycle

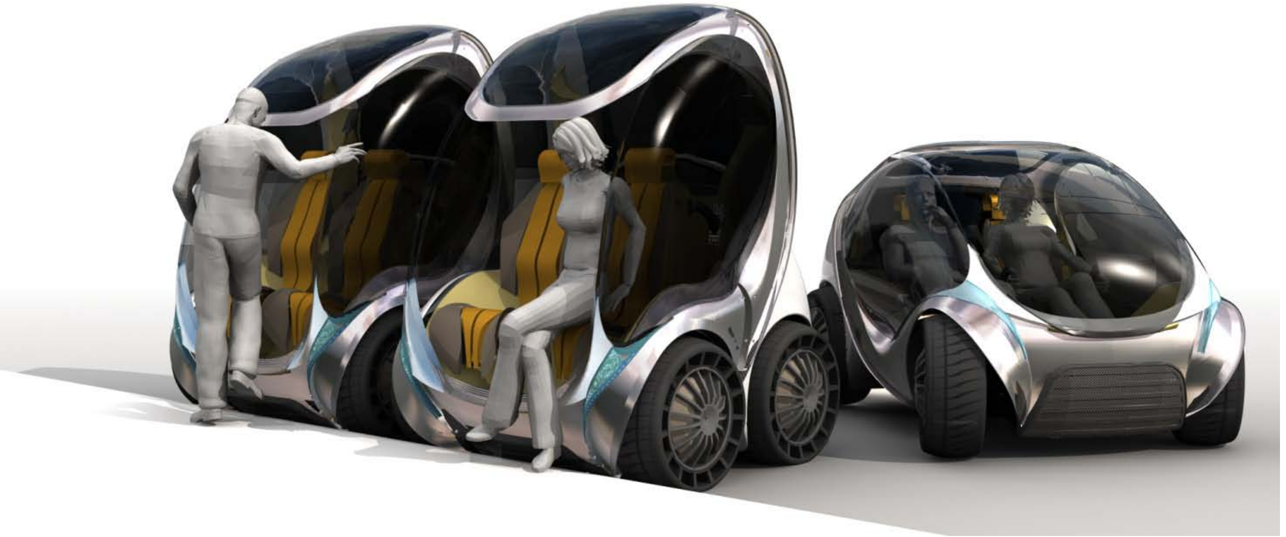
Integrated in-wheel motor and battery hub system

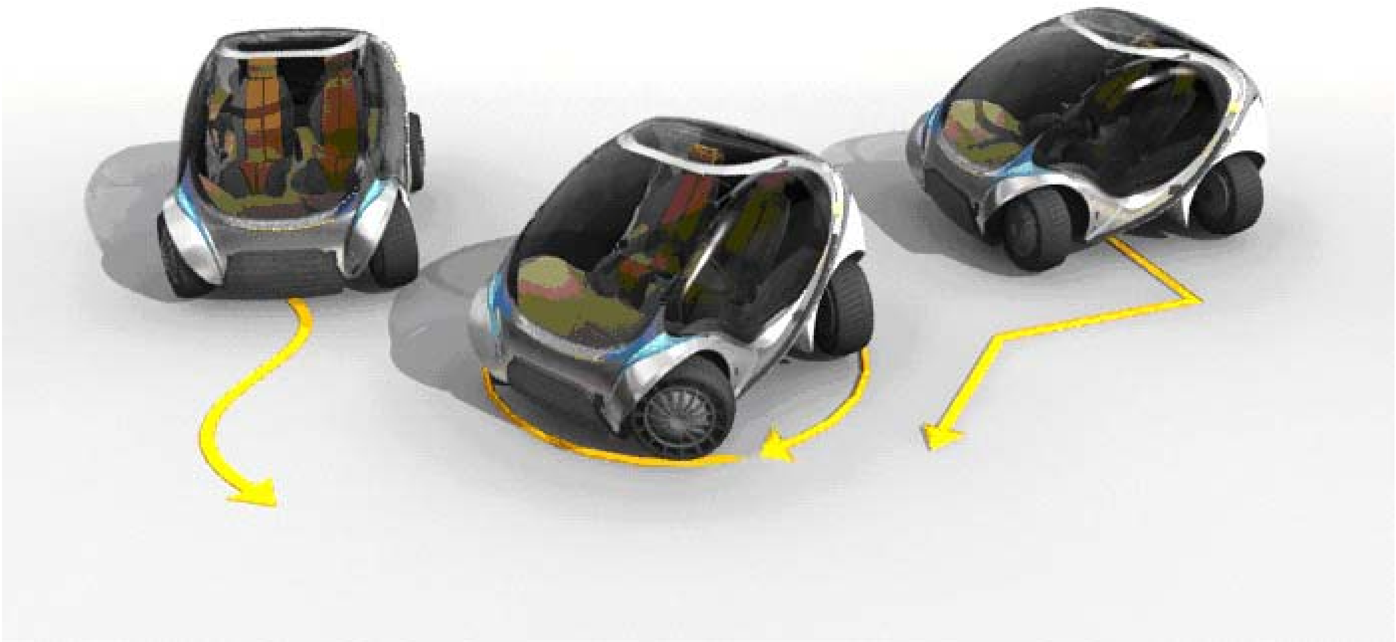
GreenWheel
Cut-away

GreenWheel Video

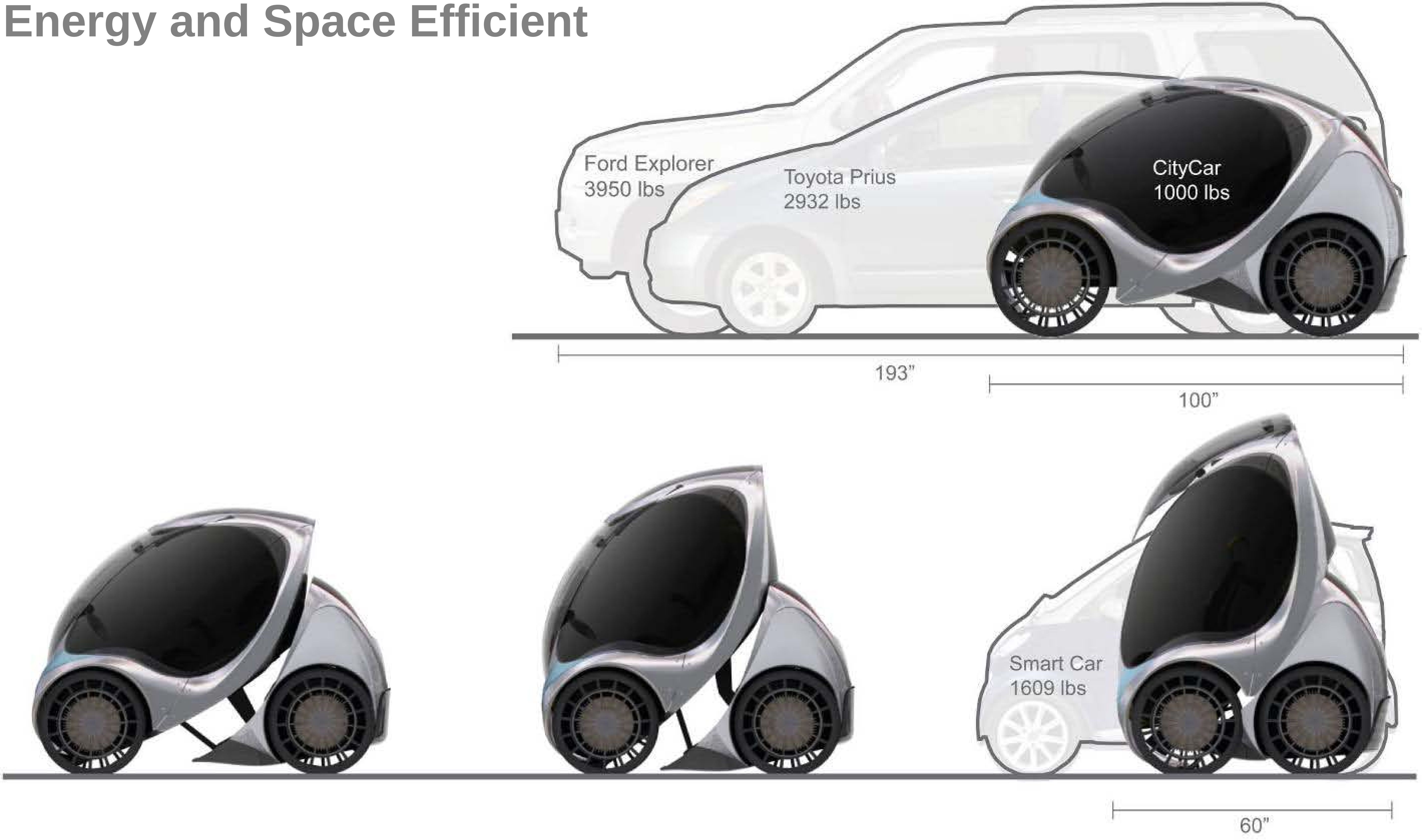
CityCar Video

Access and Maneuverability





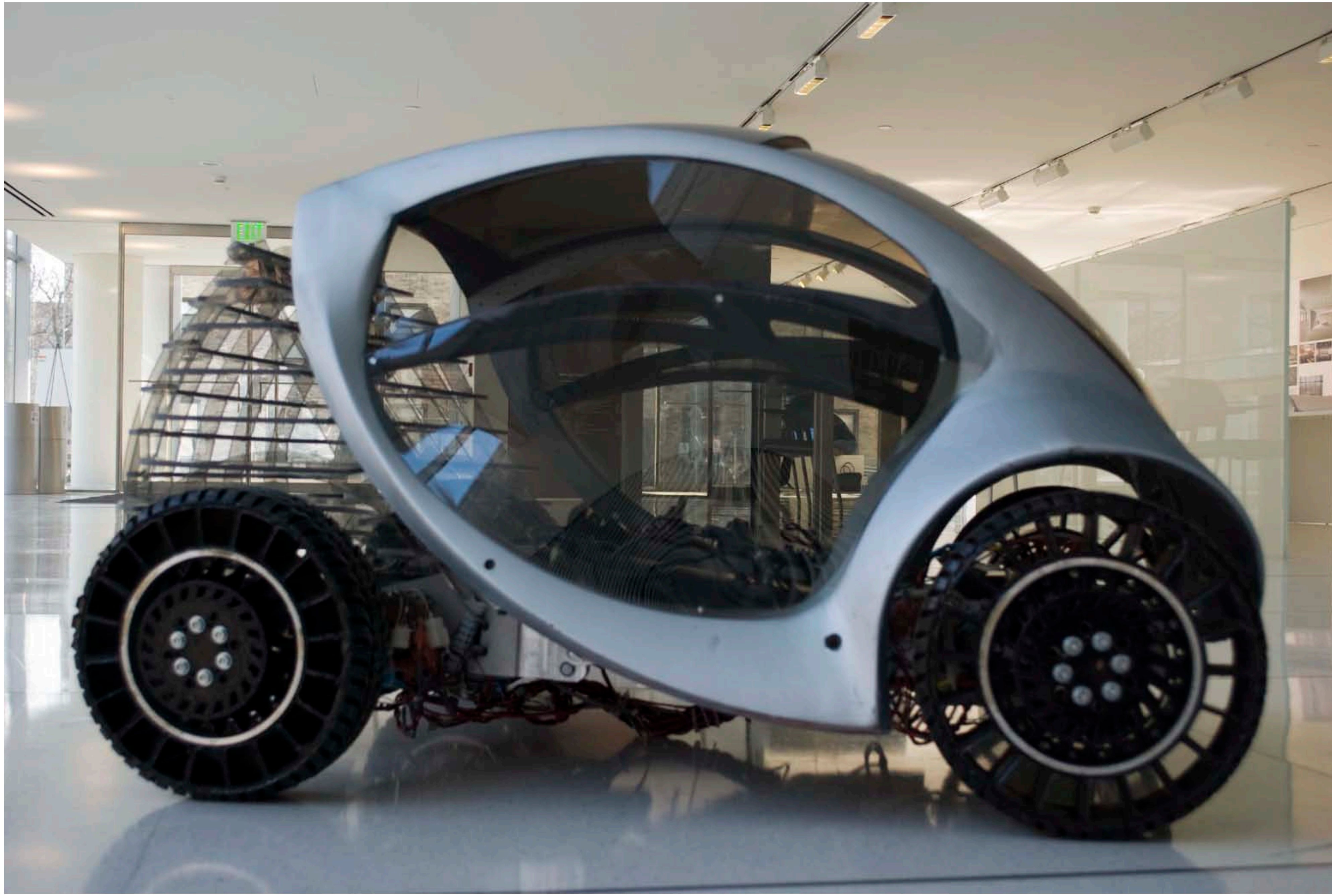
Energy and Space Efficient



Exploded View: Modules and Components

Exploded View: Modules and Components

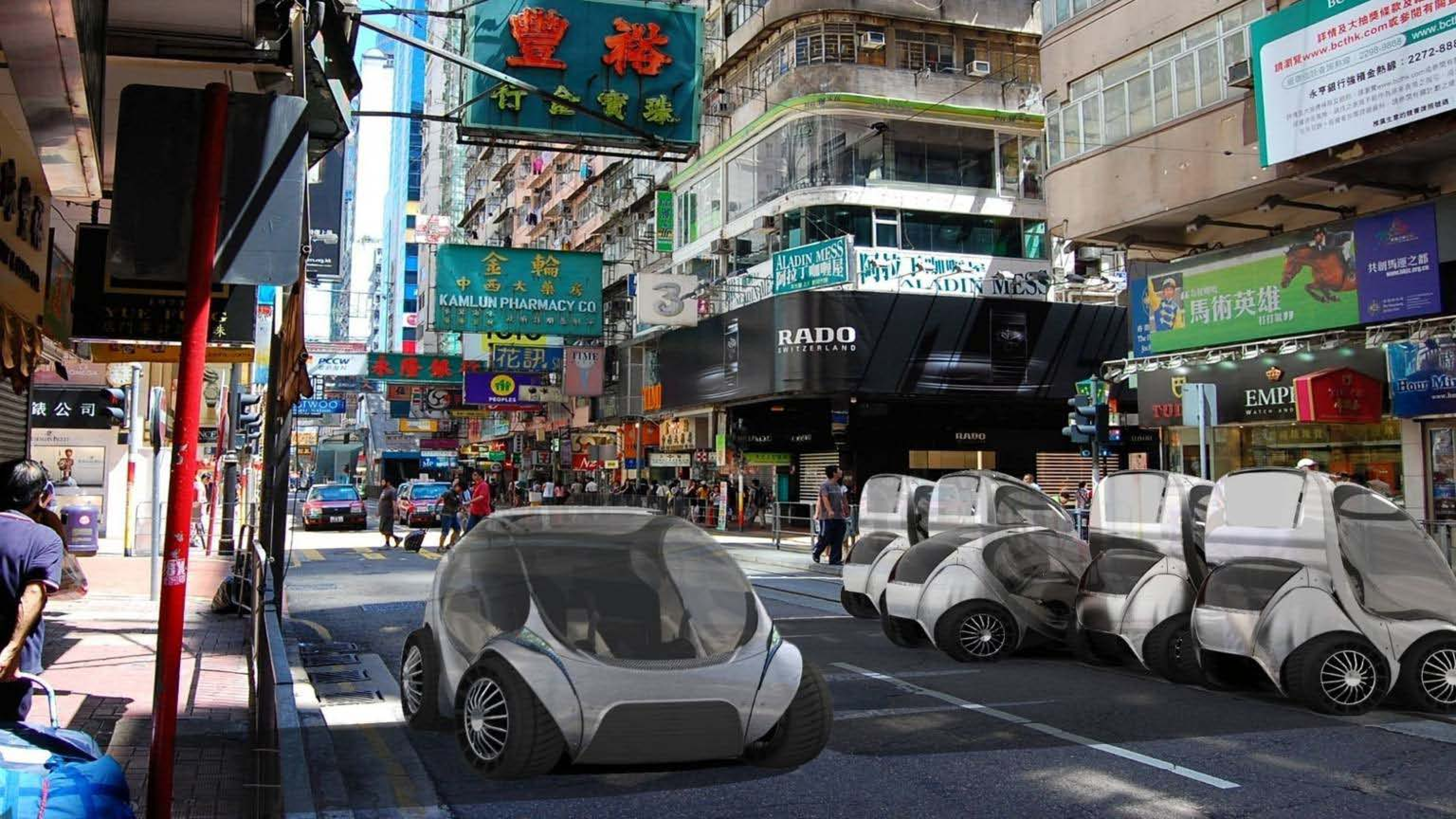
CityCar Half-Scale Prototype



CityCar Folding Sequence

CityCar Folding Chassis

CityCar Half-Scale Prototype Video



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ALADIN MESS
RADO
SWITZERLAND
RADO
馬術英雄
共創馬運之都
PCCW
PEOPLES
花訊
3


Mod Salon
時尚坊
meplus
Walker Shop
UNI
QLO
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Max Height Limit 3.0m
Passenger Pick-Up Point
Taxi Stand For 2 Taxis


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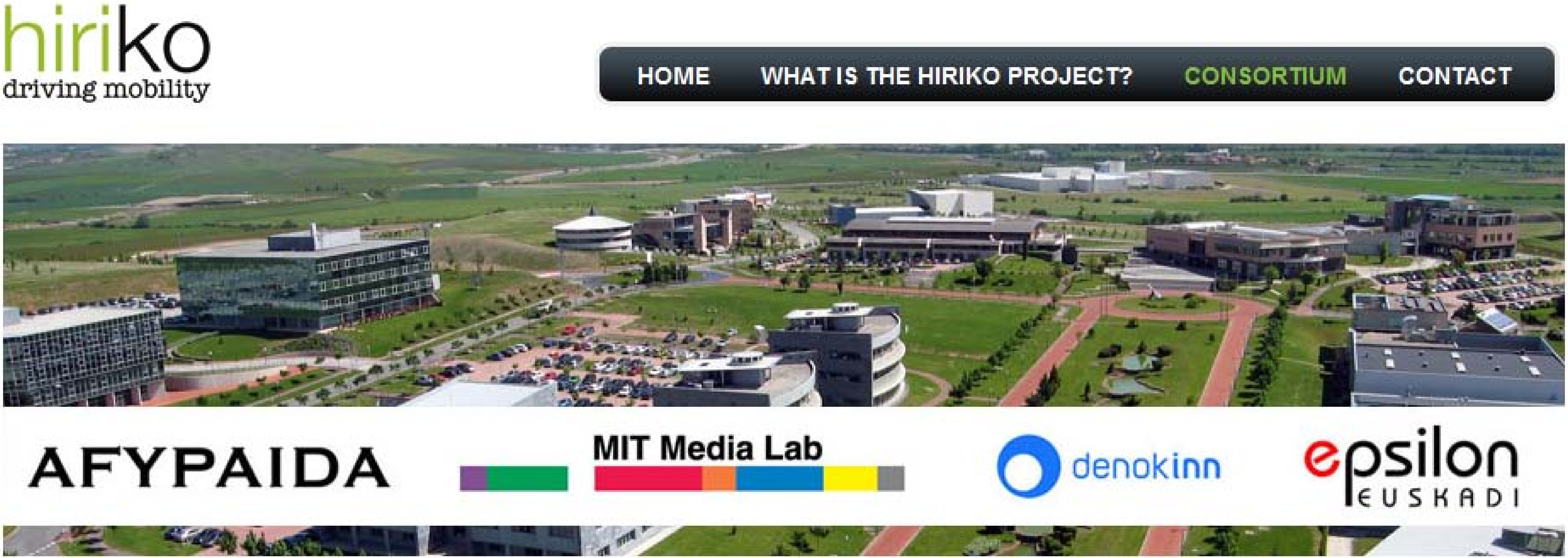
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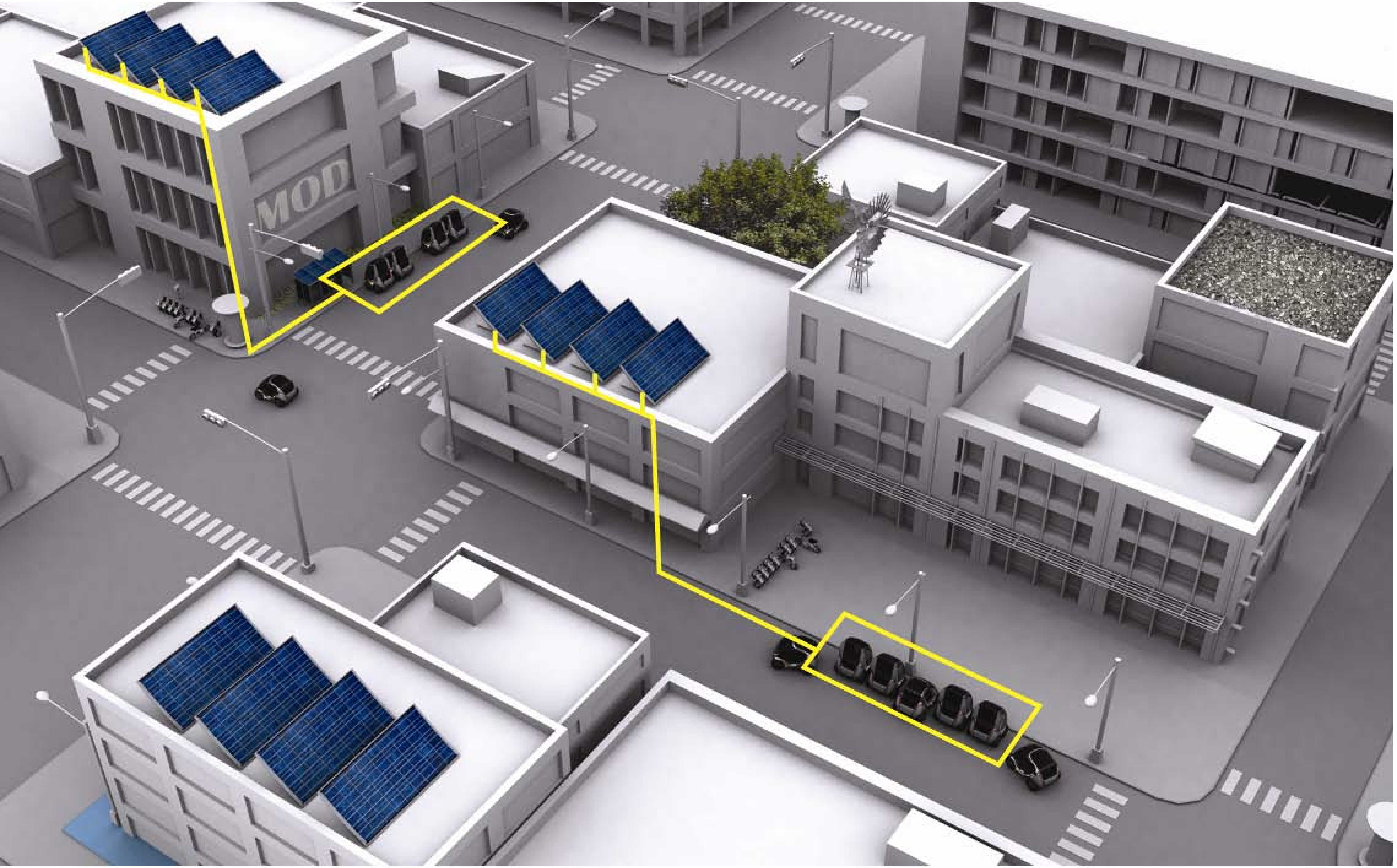
Smart Grids | Electric Charging Infrastructure

Renewable Power, Energy Storage, and Smart Grids

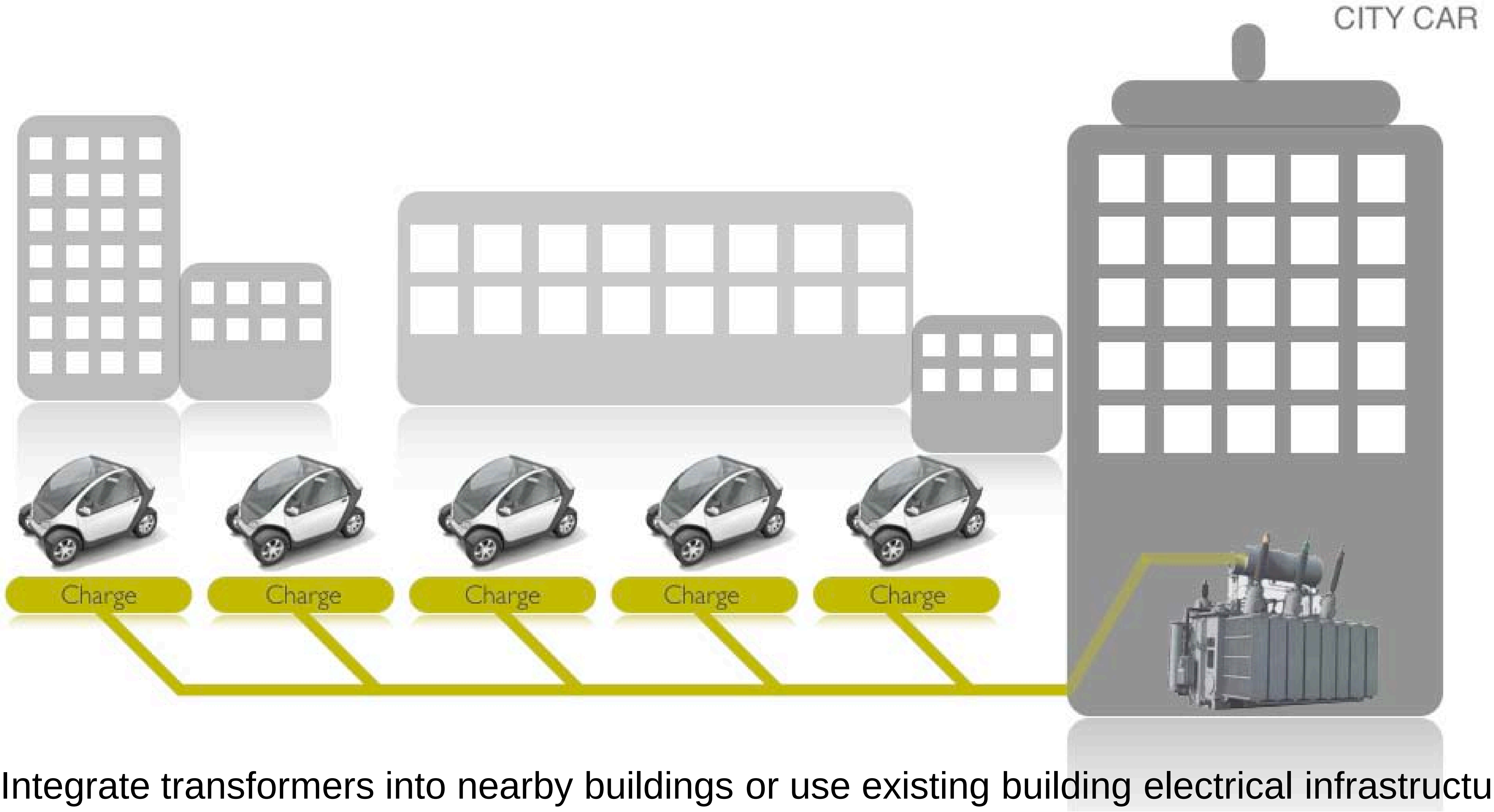


With large-scale use, car stacks throw enormous battery capacity into the electrical grid.

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

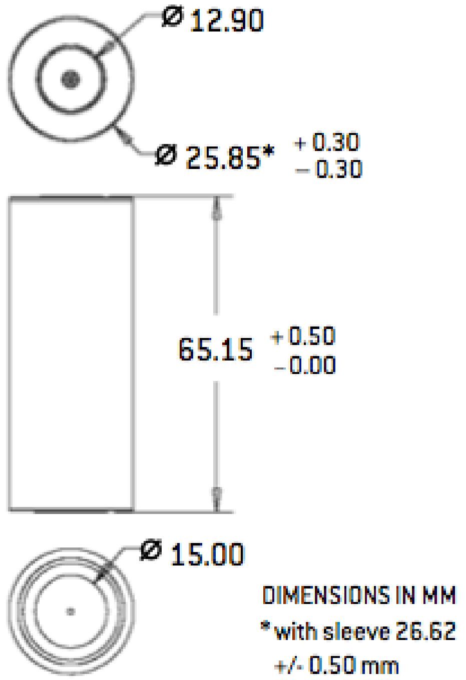


Integrate transformers into nearby buildings or use existing building electrical infrastructure

Battery Performance and Specifications

Lithium-ion battery cells based on nano-phosphate electrode technology to provide low impedance batteries that can be rapidly recharged.
-Typical battery cost is about 300-700 Euros per Kilowatt-hr

26650 Cell: Delivers 2.3 Amp-hours at 3.3V
-Fast charge (15 min) at 10A to
` 3.6V (36 Watts/cell).



HD Prismatic Cell: Delivers 20 Amp-hours at 3.3V
-Fast charging research in progress by EVT.
-Similar rapid-charging characteristics as 26650.

CityCar: 5 to 15 kW/hr battery pack. Using 10 kW/hr as benchmark:
- Target weight of vehicle is 1000 lbs ≈ 450 kg
- Approx. 150 Watt-hrs/mile
- Requires ~1320 26650 cylindrical cells or ~150 HD prismatic cells
- Target cost < 2000 Euros per 5 kW/hr battery pack

Vehicle Charge Times by Power Source

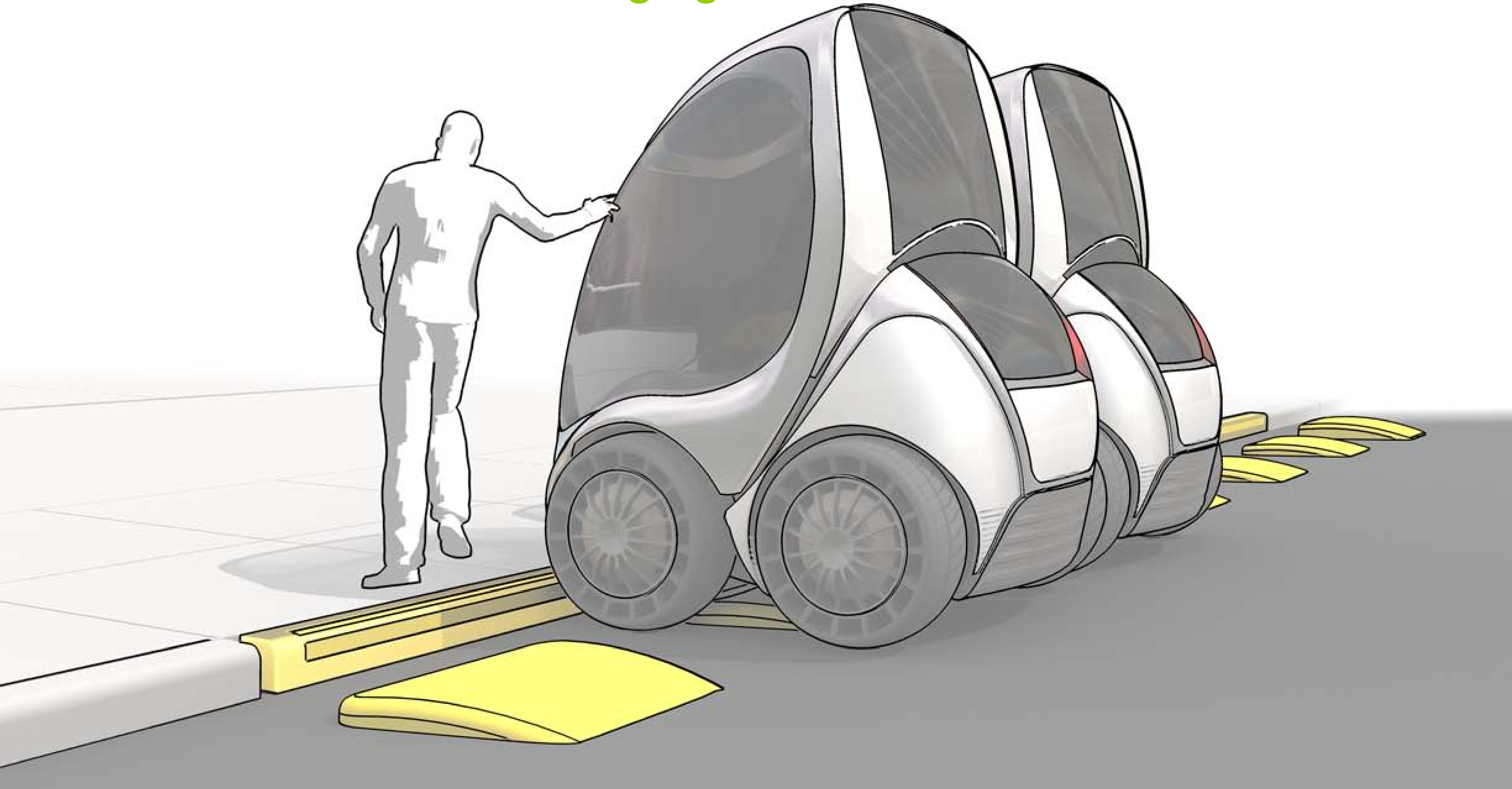
Vehicle Charge Times by Power Source

Vehicle	Pack Size (kWh)	120V, 15 A: 1.8 KW (~ 2 x)	220V, 50 A: 11 KW (~ 11 x)	220V, 200 A: 44 KW (~ 44 x)	480V, 400 A: 330 KW* (~ 330 x)	480V, 1000 A: 830 KW* (~ 830 x)
GreenWheel	0.2	7 min	1 min	< 1 min	< 1 min	< 1 min
RoboScooter	0.5	17 min	3 min	< 1 min	< 1 min	< 1 min
Motorcycle (60 mi)	5	3 hours	27 min	7 min	< 1 min	< 1 min
CityCar	10	6 hours	55 min	14 min	2 min	< 1 min
Sedan (100 mi)	30	17 hours	3 hours	41 min	6 min	3 min
Taxi (180 mi)	60	34 hours	6 hours	2 hours	11 min	5 min
Public Shuttle Bus	150	84 hours	14 hours	3 hours	27 min	11 min

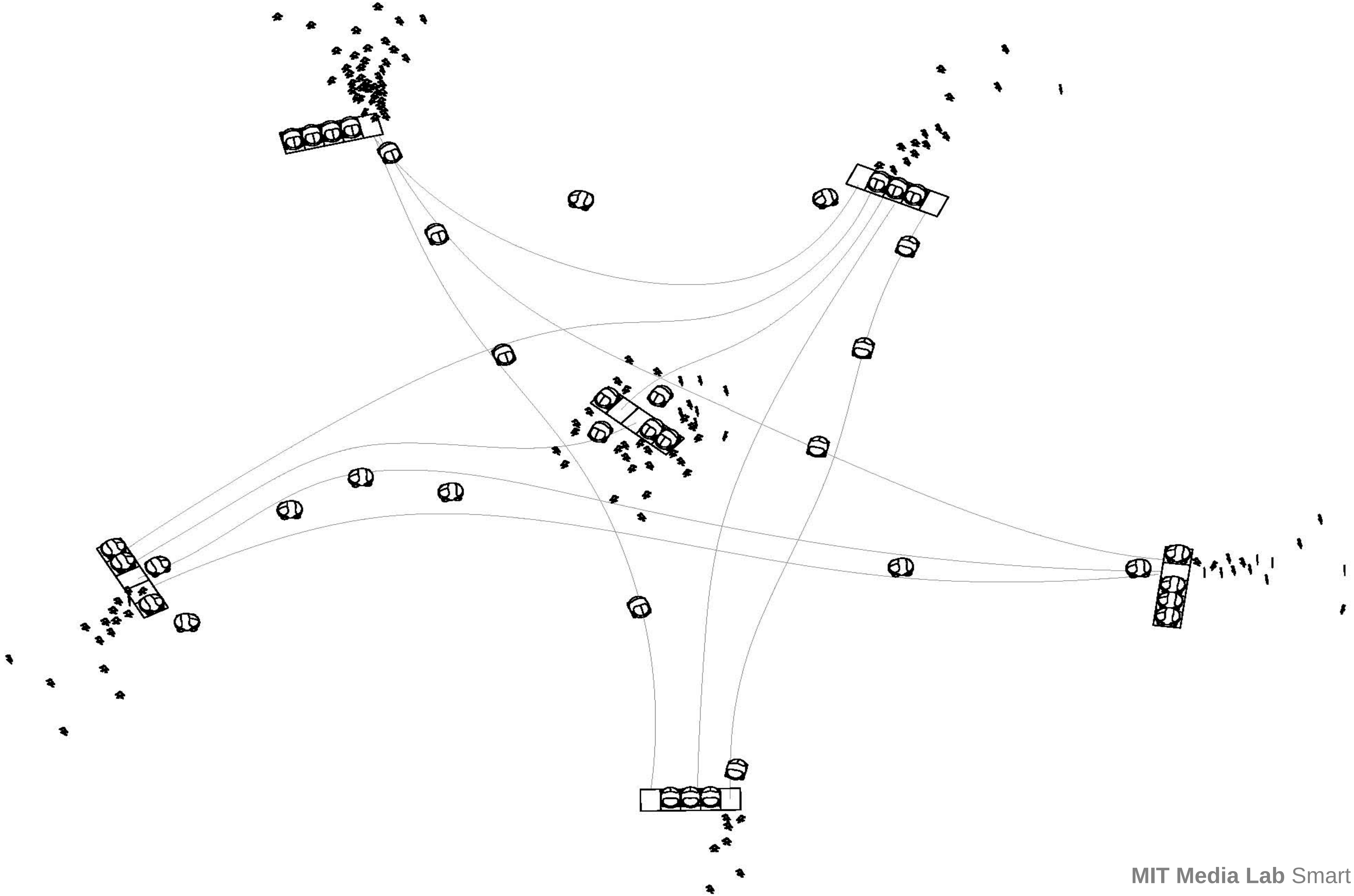
** 3-phase power: Power = sqrt(3)*Current*Voltage*

*Times calculated using ideal calculations given 100% power transfer

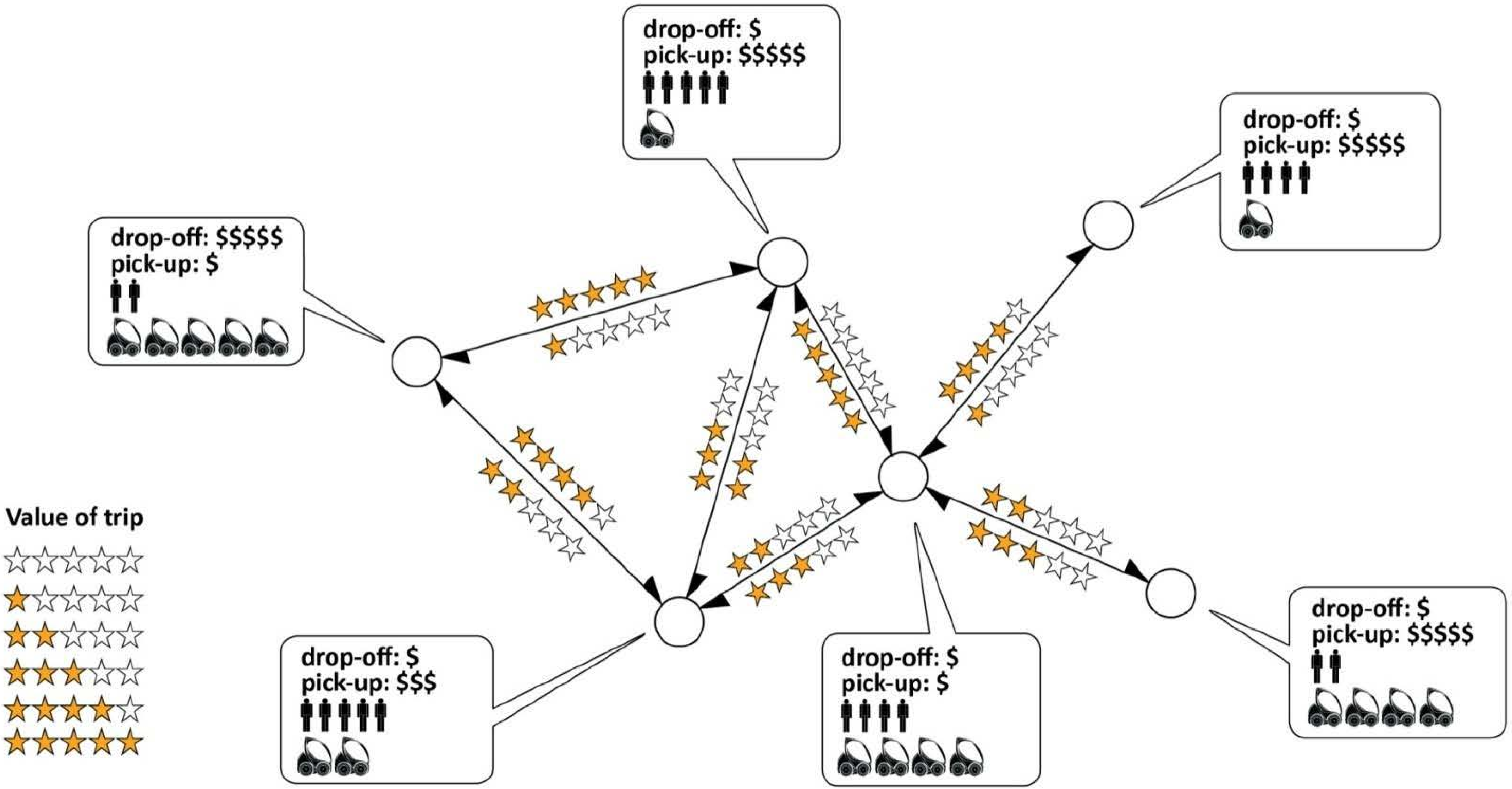
Contactless Inductive Charging



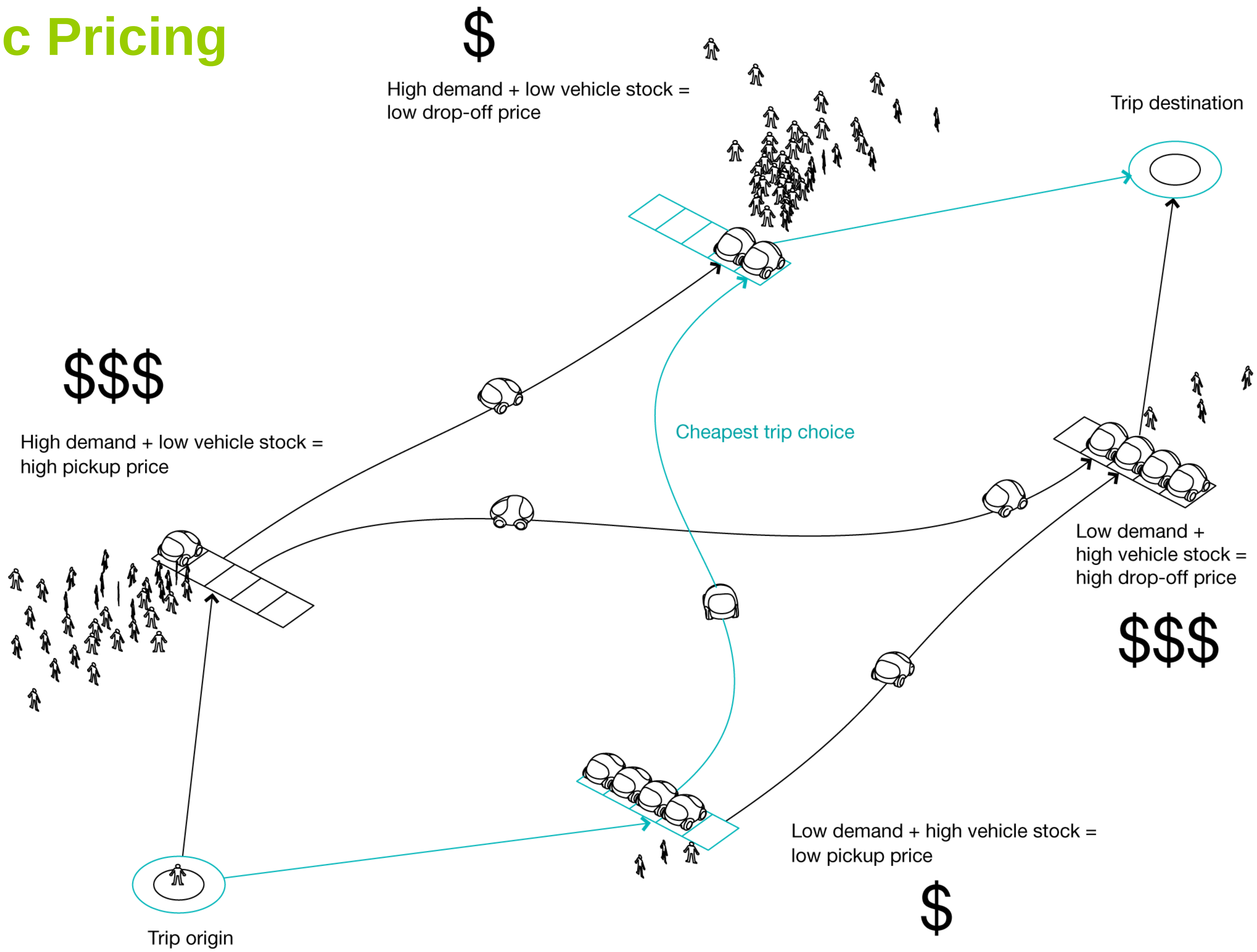
Fleet Management | System Dynamics, Logistics, and IT



Dynamic Pricing



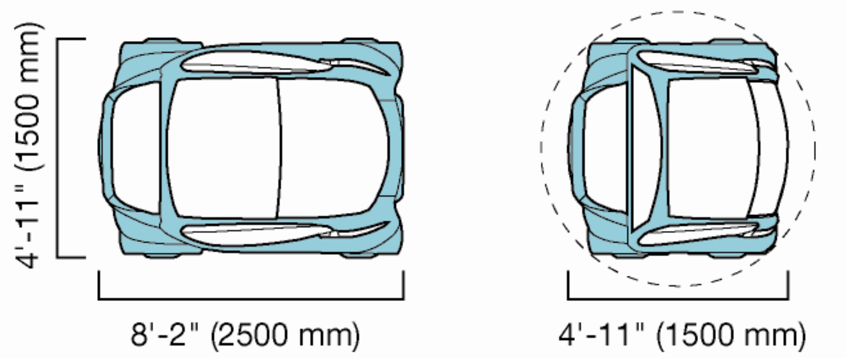
Dynamic Pricing



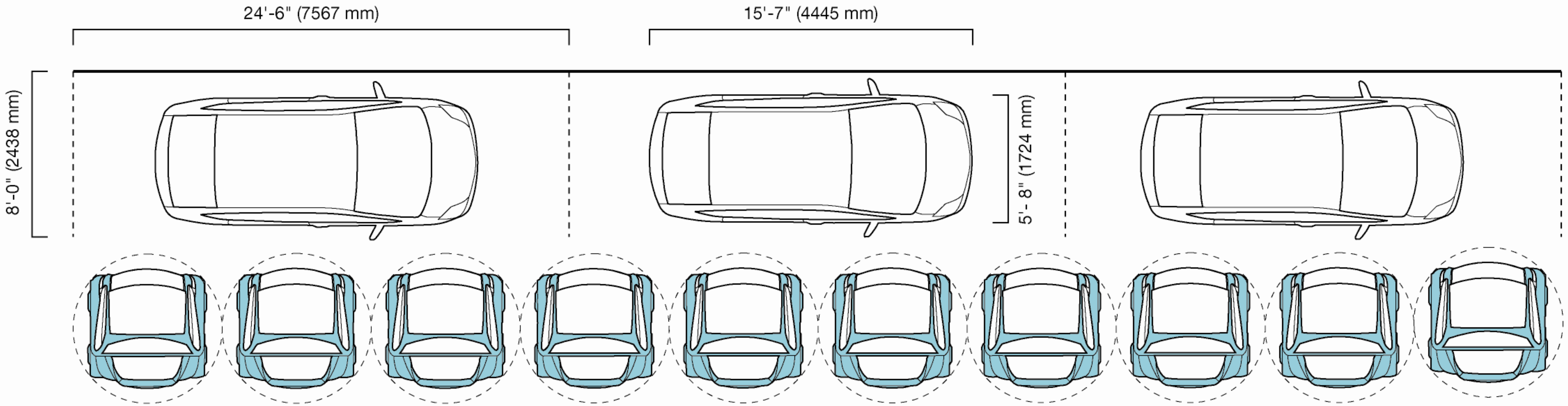
Urban Implications and deployment

Case studies in Singapore, Boston, Taipei, Florence

Parking Ratios: 3 to 1

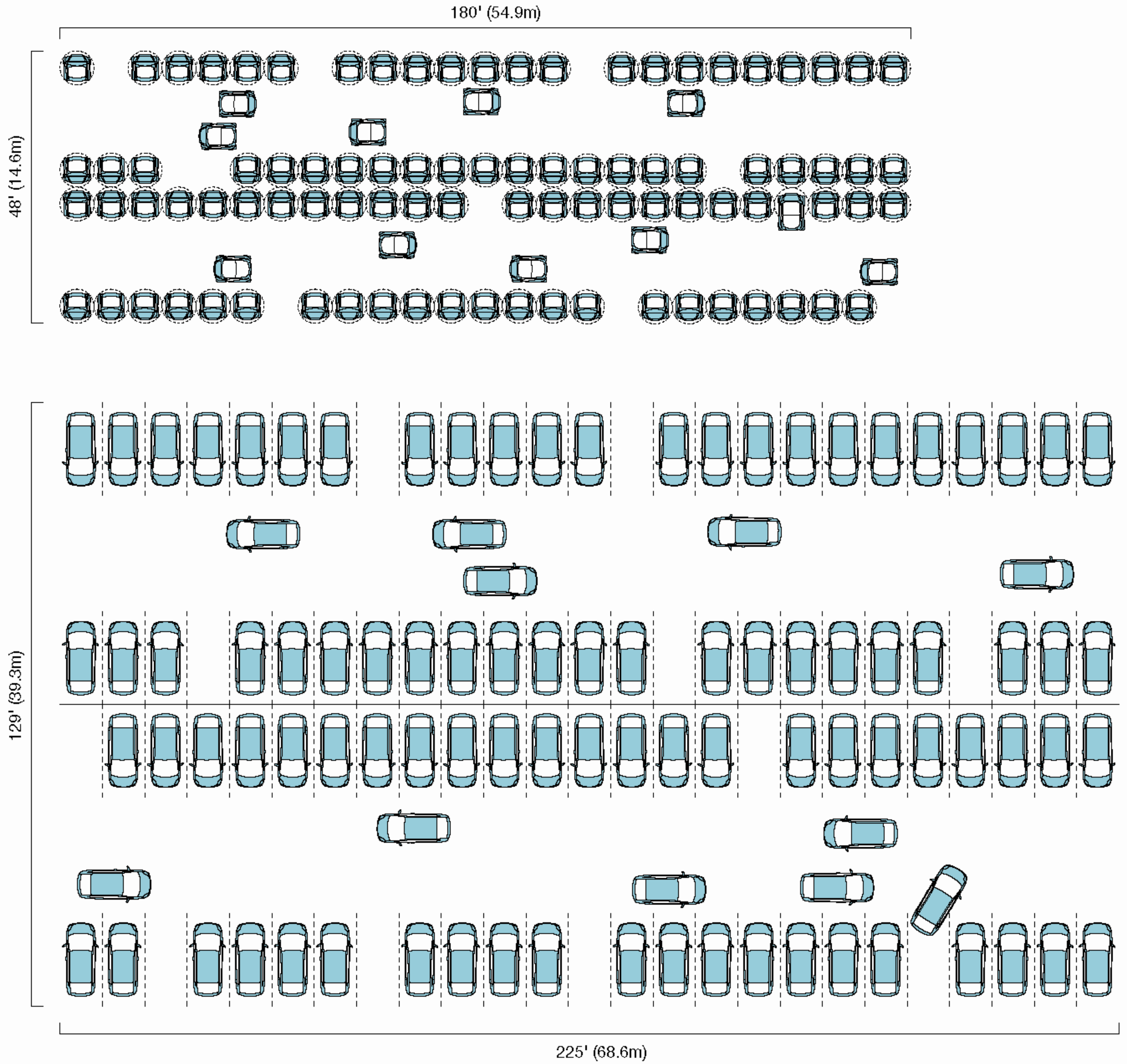


CityCar (unfolded) CityCar (folded)



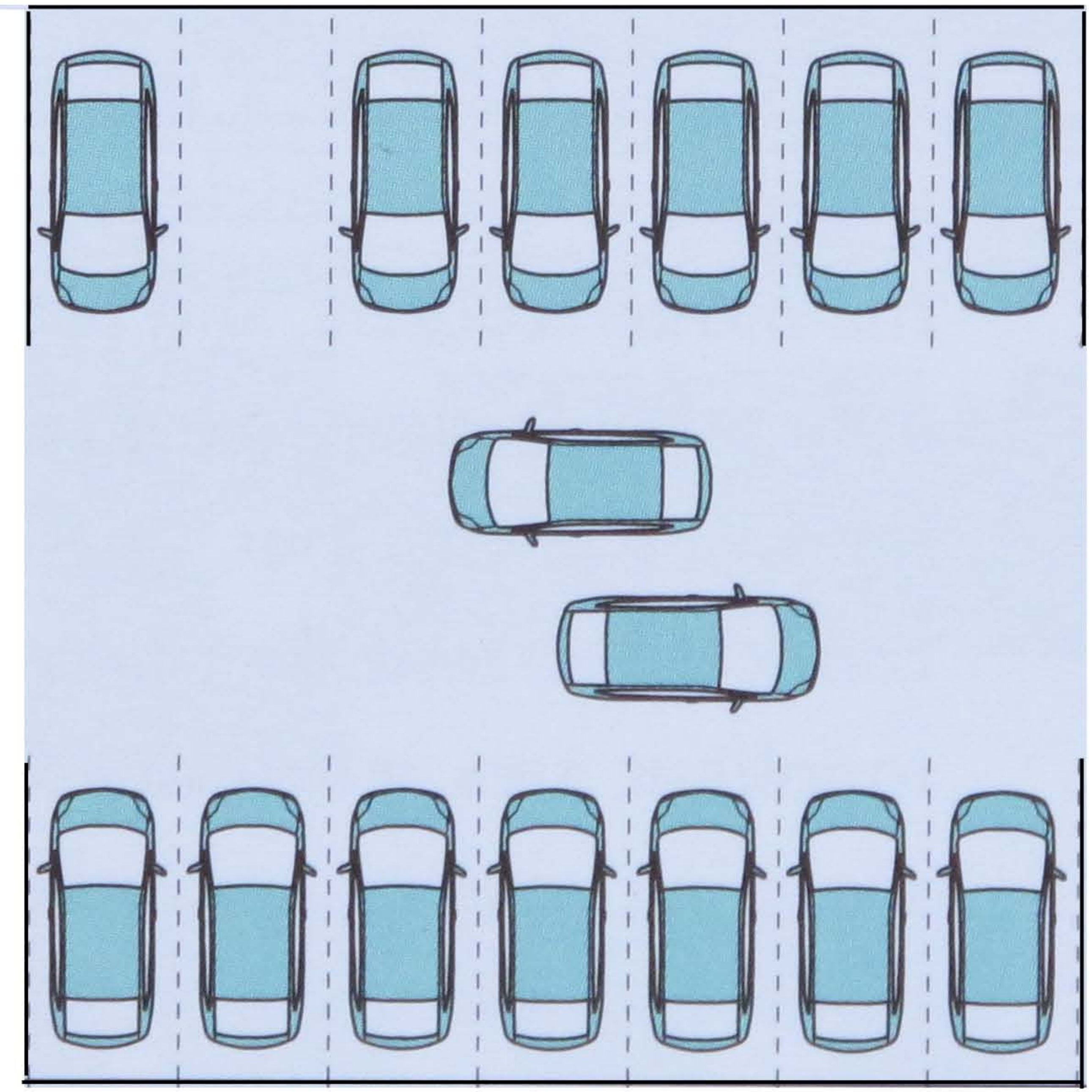
Folded CityCar vs. conventional 4-door sedan
Parking ratio = 3.3 : 1

Parking Ratios: 3 to 1

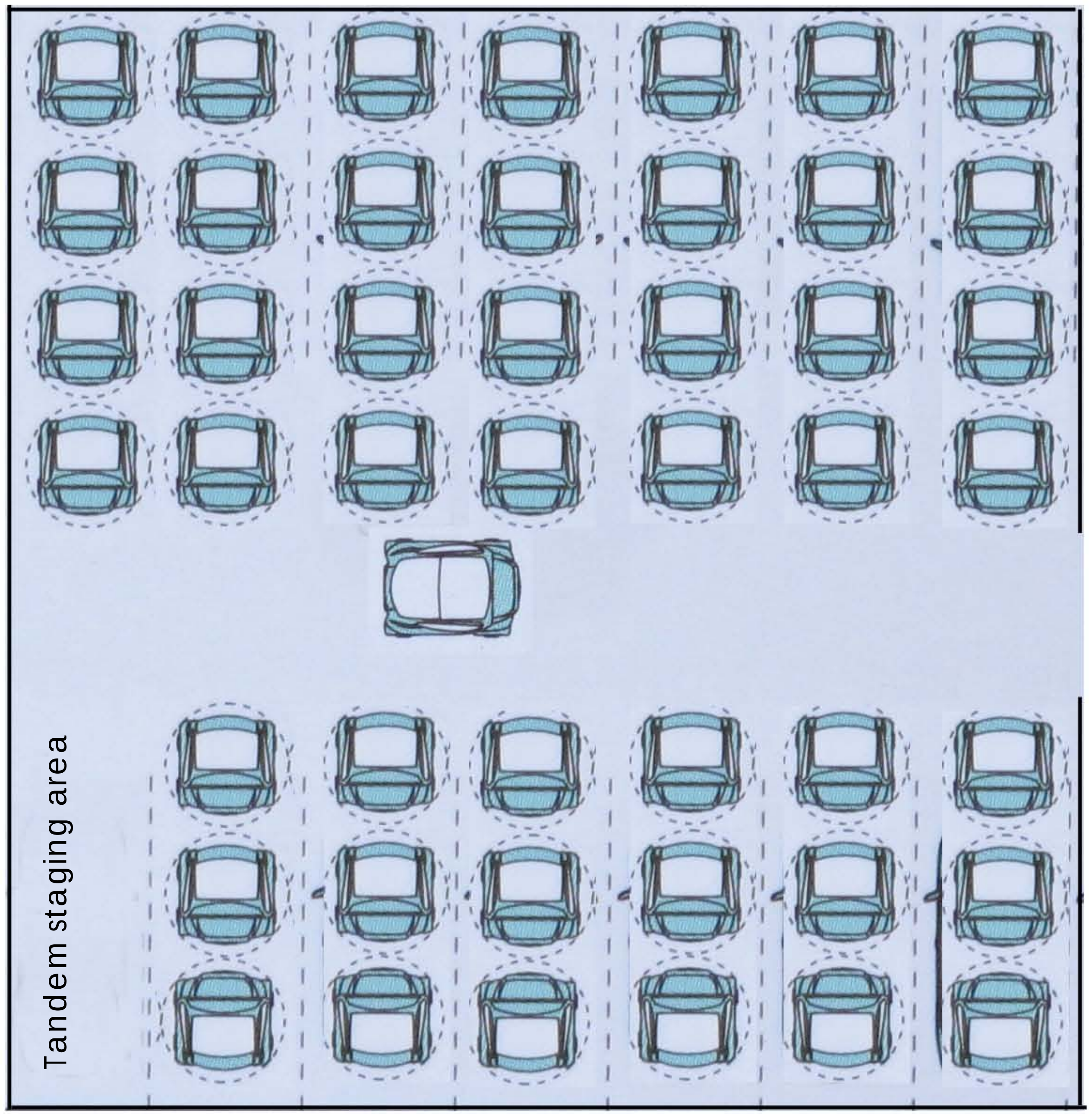


Autonomous Parking + Folding

$ 29,000 savings per vehicle for parking garage construction



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**

Typical Manhattan block (86 parking spaces)

CityCar parking with 8 stations with 12 cars each (96 cars)

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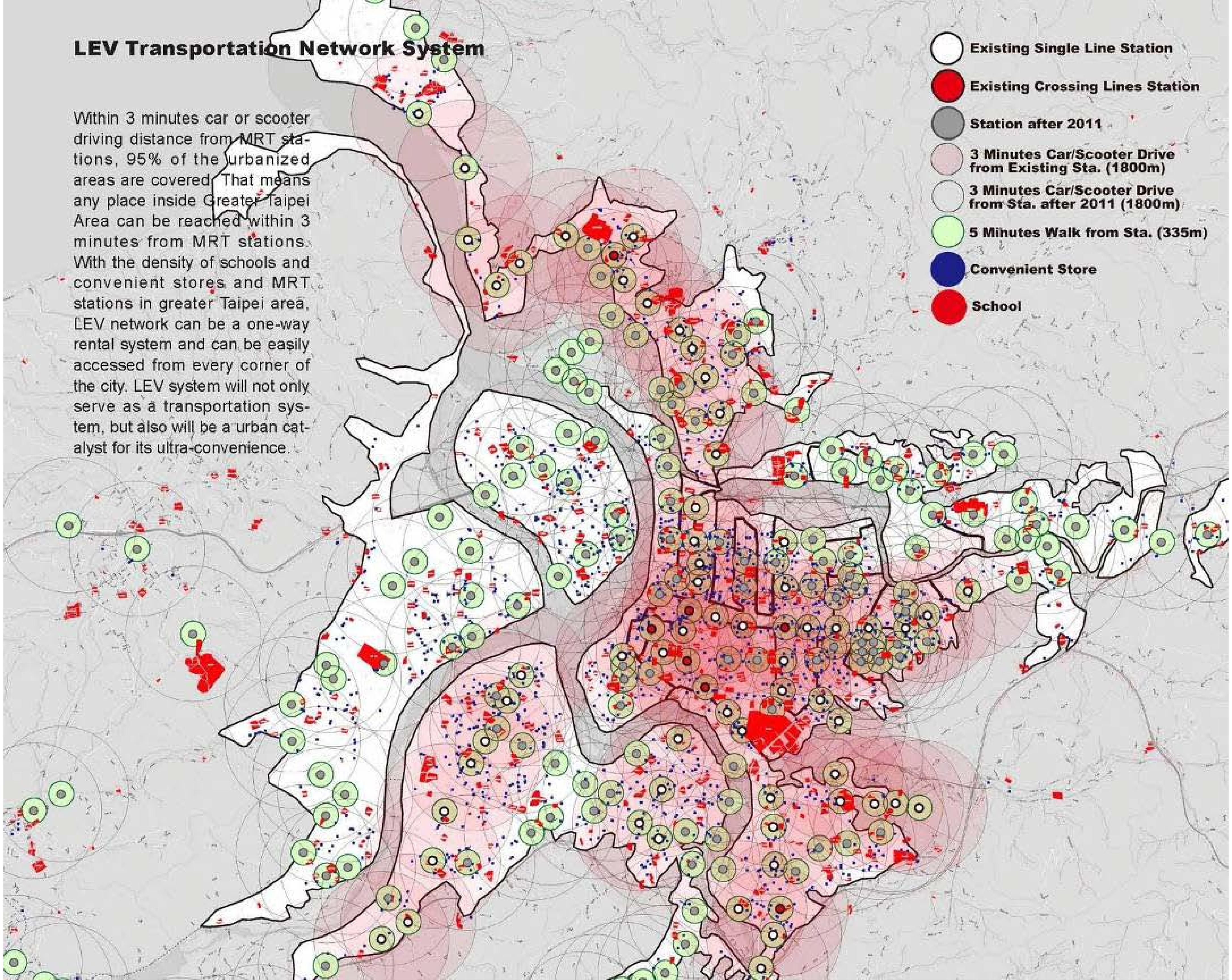
Taipei City
Implementation



Boston, MA

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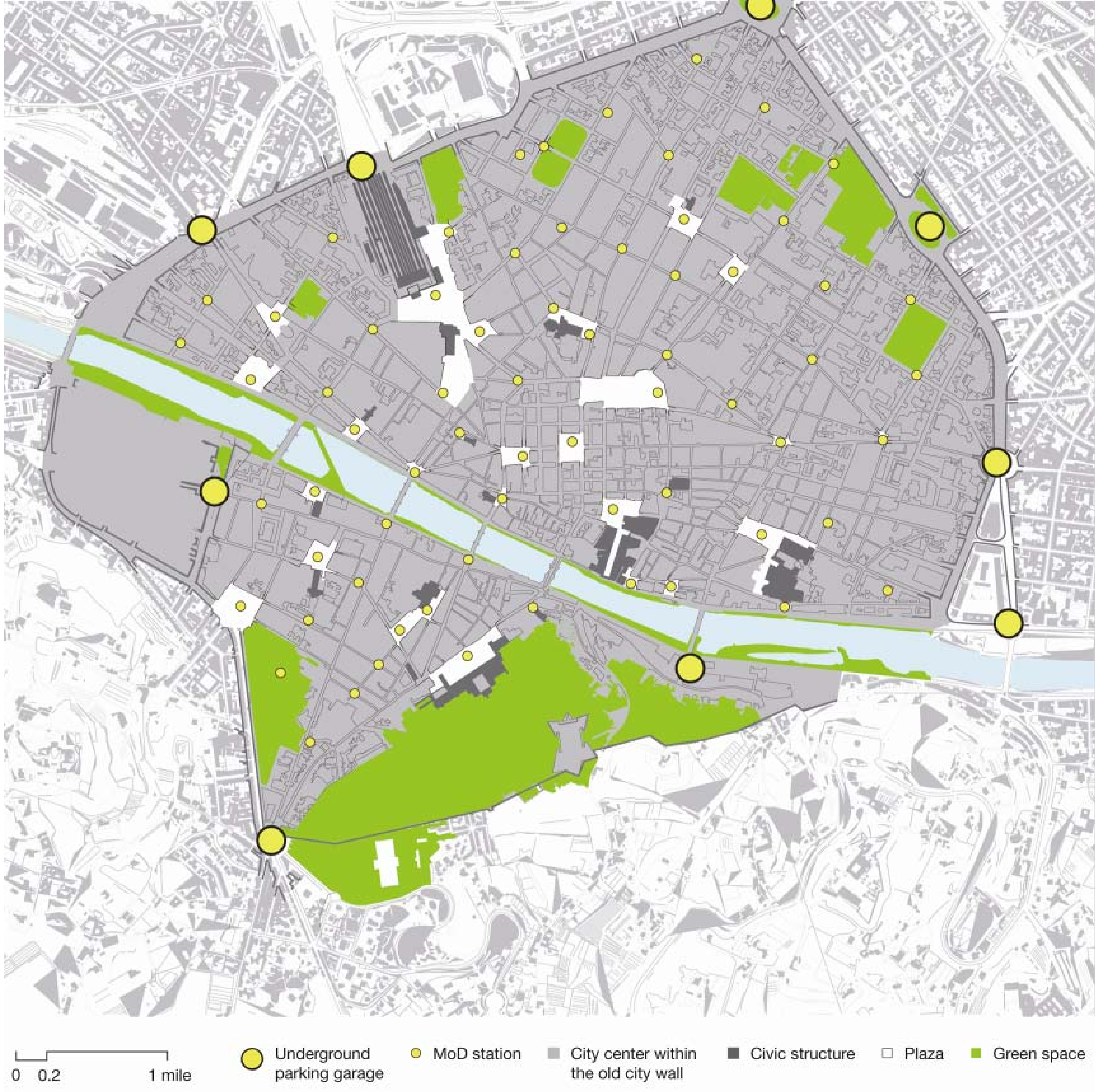
Florence, Italy



Thank You | MIT Media Lab **Smart Cities Group**

"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

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