

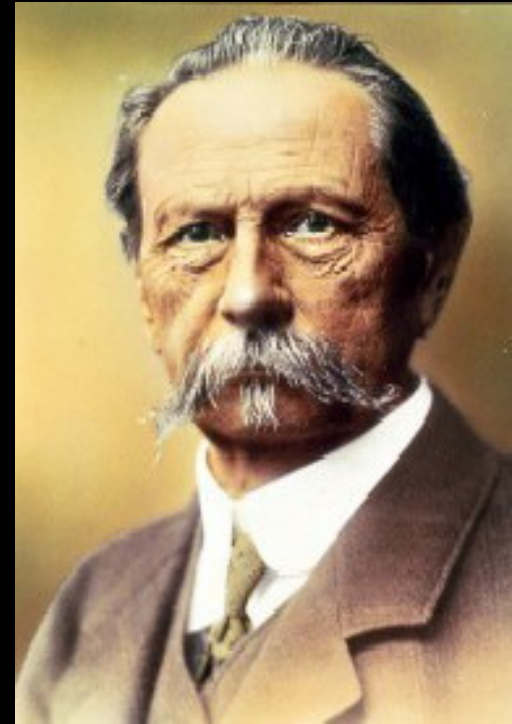
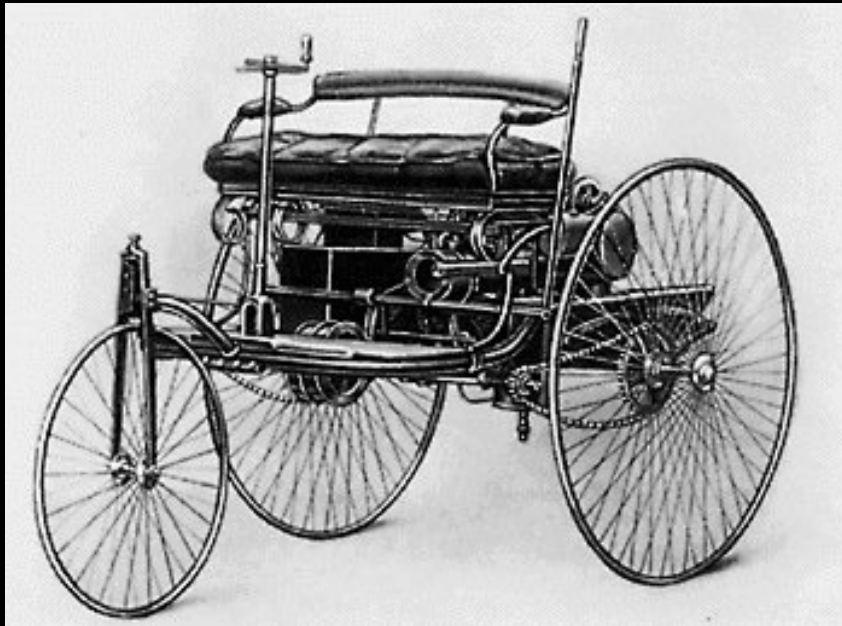
# Reinventing the Automobile

FISITA World Automotive Summit  
Mainz, Germany  
November 17, 2011

Lawrence D. Burns

# 1886: From Horses to Horsepower

Karl Benz Granted Patent for First Gasoline  
Powered Automobile



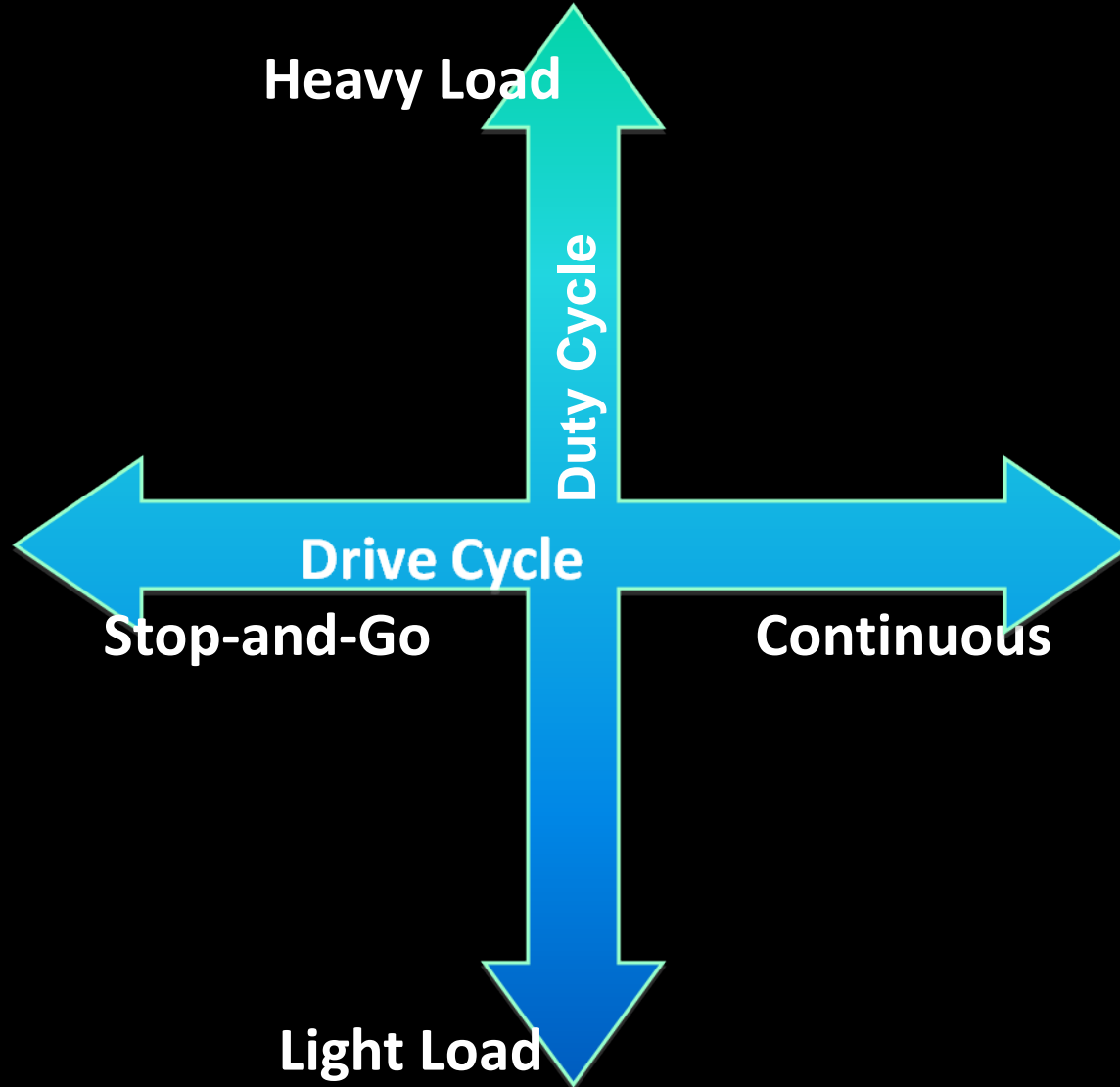
# Historical Automotive “DNA”

- Mechanical Drive
- Combustion Engine
- Oil-based Fuel
- Mechanical & Hydraulic Controls
- Human Operated
- Stand-Alone
- General Purpose

# Freedom to Go ....

- Where you want
- When you want
- With others
- With Goods

# ... and With Broad Capability



~ 1 Billion  
Automobiles Worldwide

# Challenges

- **Safety:** 1.2 M roadway fatalities worldwide
- **Energy:** 95% dependent on oil
- **Congestion:** Traffic delays
- **Parking:** Land use, delays, cost
- **Environment:** CO2 emissions
- **Infrastructure:** Aging and costly

Likely Unsustainable  
Without  
Transformational Change

# Reinventing the Automobile

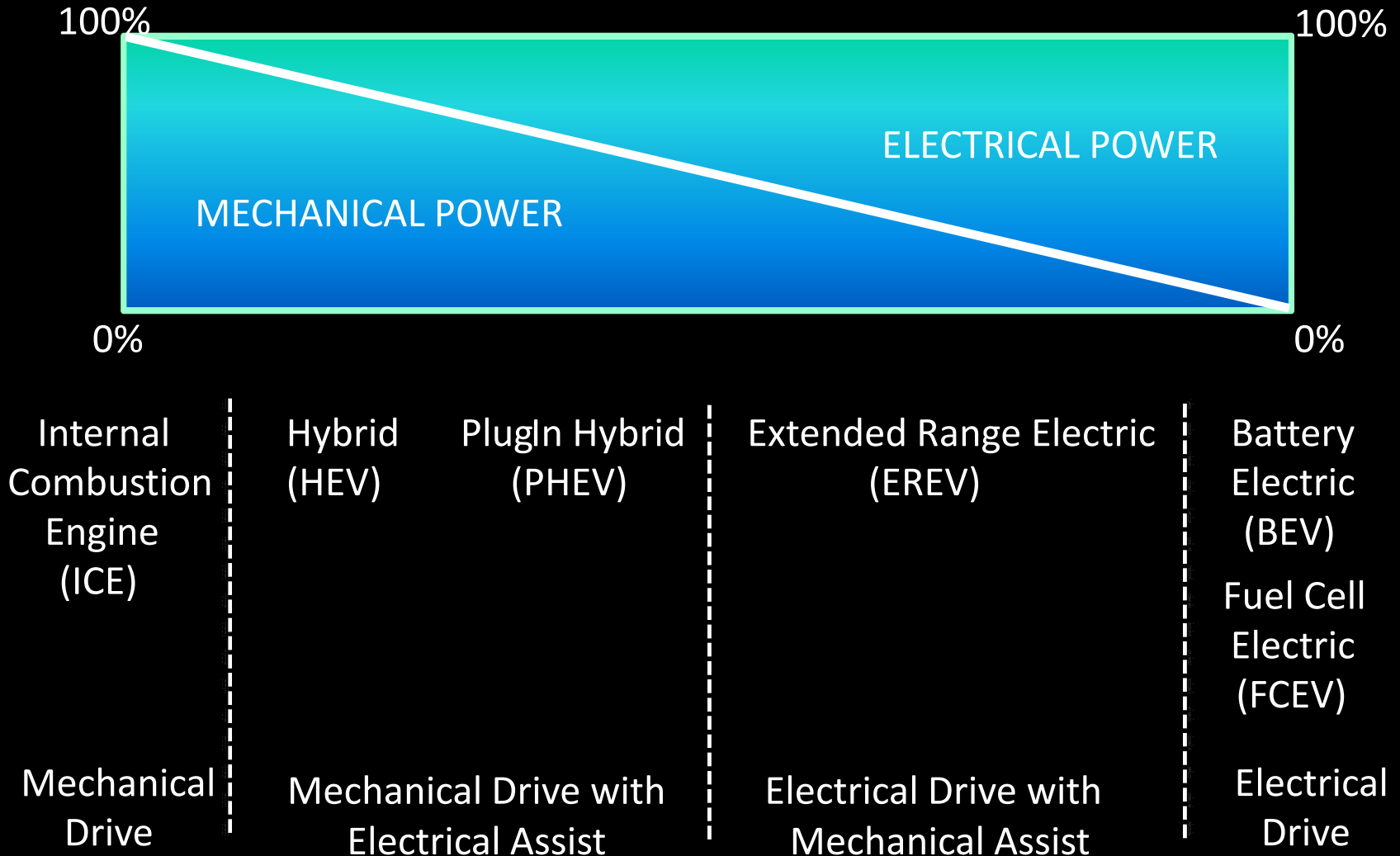
## Historical “DNA”

- Mechanical Drive
- Combustion Engines
- Oil-based Fuels
- Mechanical & Hydraulic
- Human Operated
- Stand-alone
- General Purpose

## New “DNA”

- Electrical Drive
- Electric Motors
- Diverse Energy Sources
- Electronic & Digital
- Driverless
- “Connected ” and Coordinated
- Specific Purpose

# Vehicle Electrification

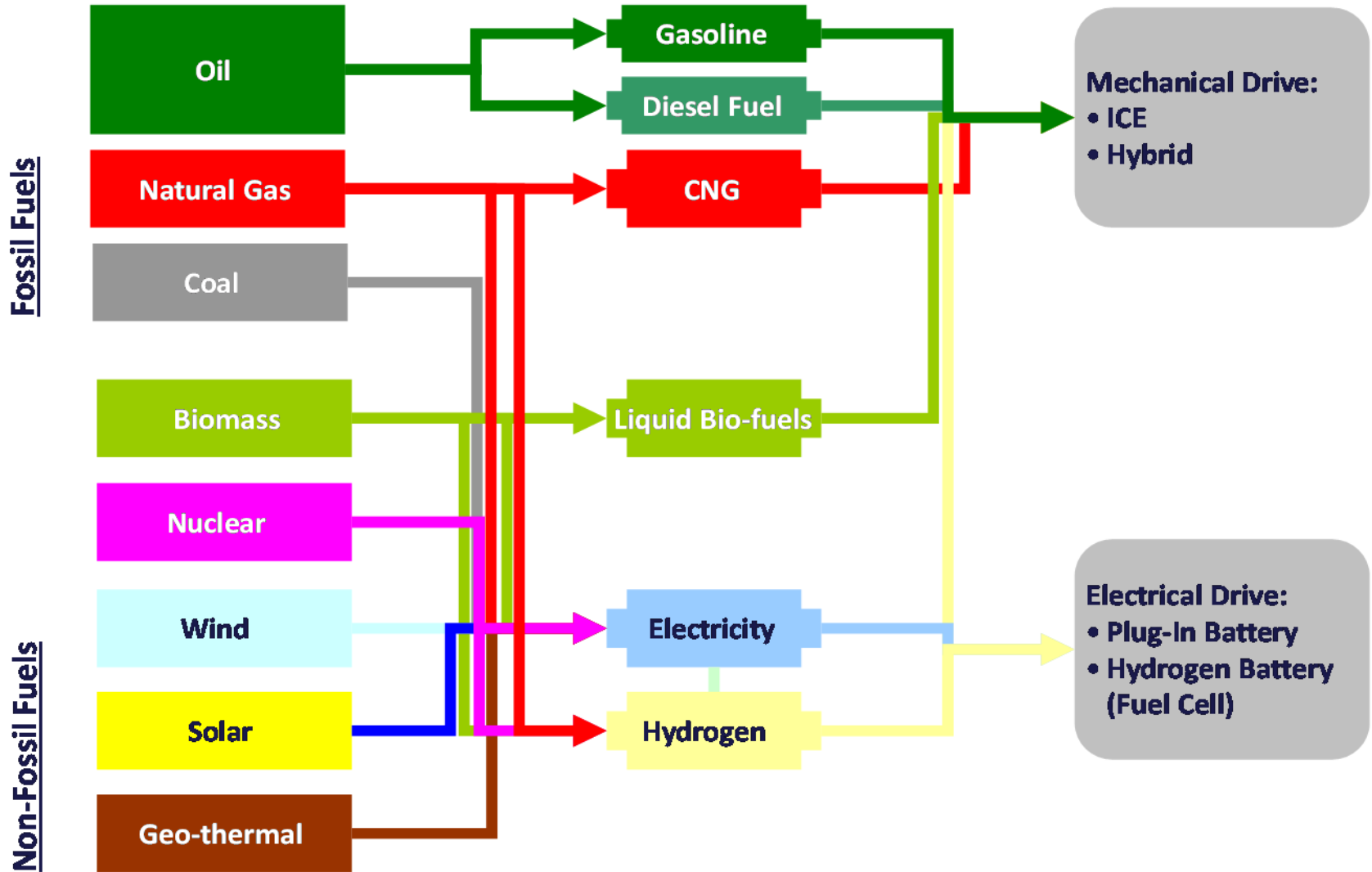


# Road Transportation Energy Supply

Energy Sources

Onboard Vehicle Energy Carrier

Vehicle Propulsion



# Non-Oil Energy Pathways

## Natural Gas

- Compressed or Liquid → ICE
- Burn → Electricity → Plug-in EV
- Reform → Hydrogen → Fuel Cell EV or ICE

## Biomass

- Liquid → ICE
- Burn → Electricity → Plug-in EV
- Reform → Hydrogen → Fuel Cell EV

## Wind or Solar

- Electricity → Plug-in EV
- Electrolysis → Hydrogen → Fuel Cell EV

# Driverless Vehicles



DARPA Urban Challenge



Google Self-Driving Car

# Driverless Vehicles Are Compelling

- More value from time in vehicles
  - "driving is a distraction!"
  - 1 hr/day X \$25/hr X 250 days/yr = \$6,250/yr
  - 1 hr/day X \$50/hr X 250 days/yr = \$12,500/yr
- Vehicles that don't crash
  - eliminate roadway fatalities, injuries and property damage
  - enable lighter vehicles
- Lighter vehicles
  - enhance energy efficiency
  - enable better use of batteries (both plug-in and hydrogen)

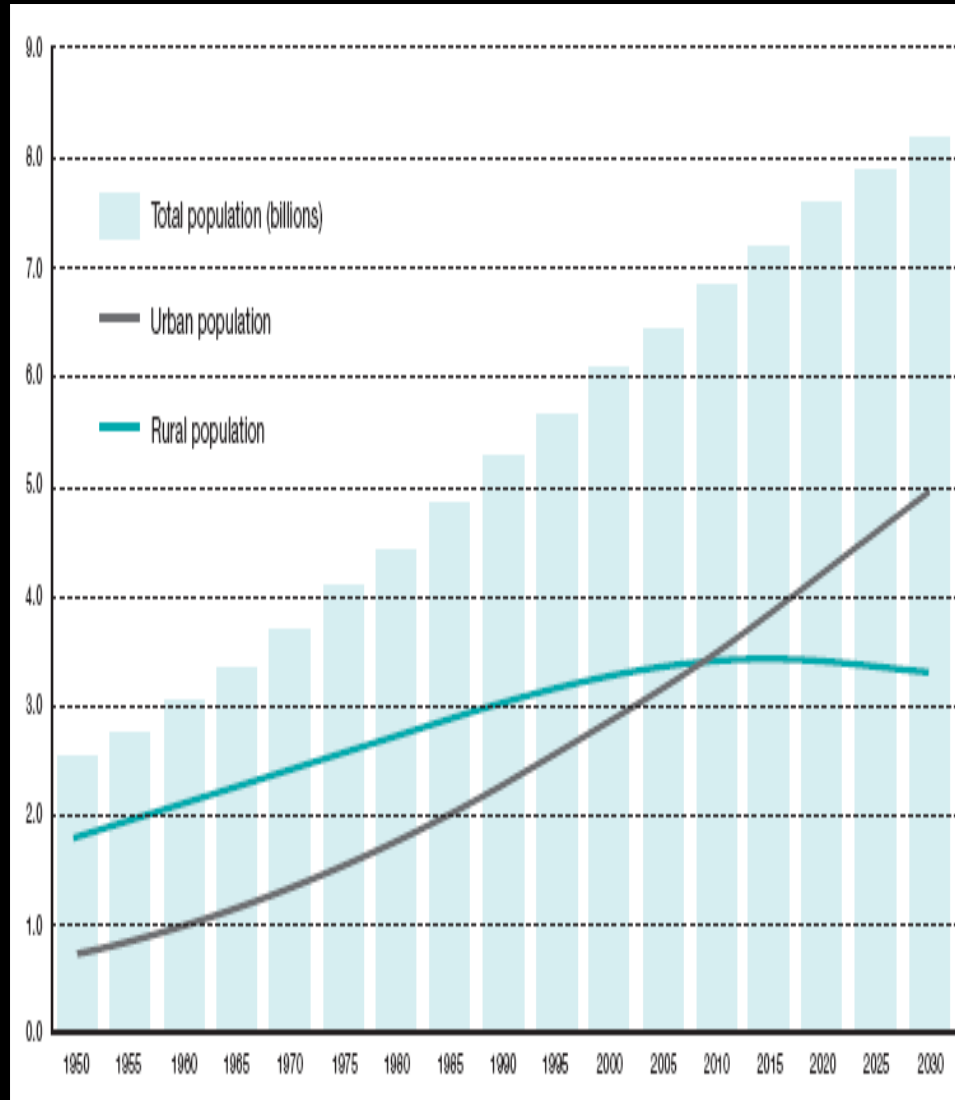
# Mobility Internet: “Connected” and Coordinated

- Manages huge amounts of spatial and temporal “connectivity” data
  - people
  - goods
  - vehicles
  - Infrastructure
- Coordinates precisely
  - “millimeters and milliseconds”
  - “mega-meters and hours”
- Optimizes
  - safe traffic flow
  - road and parking space use
  - vehicle fleets
  - energy supply
- Does for vehicles what the Information Internet did for computers

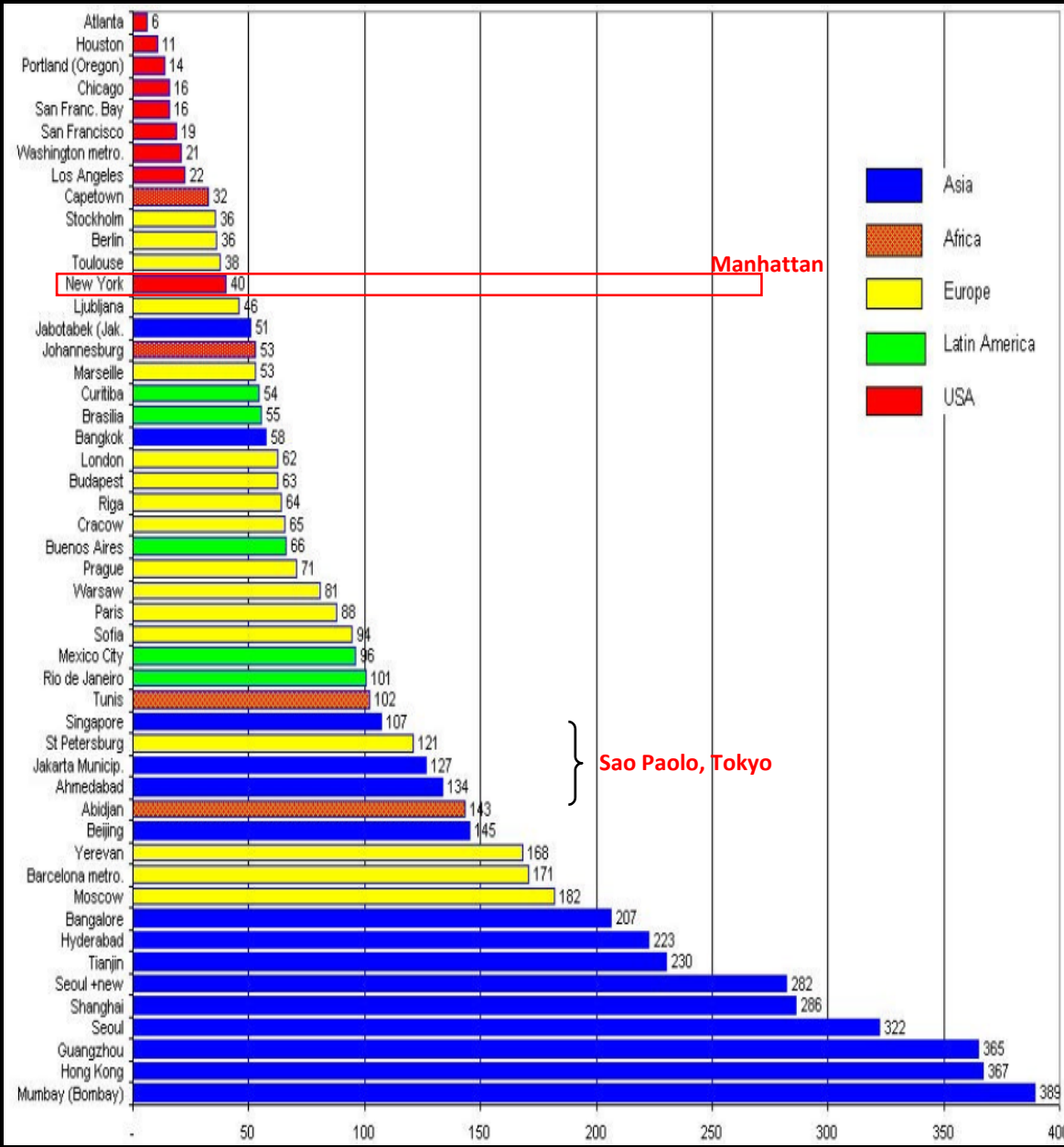
# Specific Purpose Designs

- “Tailored” to
  - Driving cycles
  - Duty cycles
  - Trip characteristics (length, occupancy, top speed, ...)
- More efficient
  - Energy
  - Space
  - Time
  - Cost
- Enabled by
  - Less mass
  - Fewer parts
  - New proportions
  - “By-wire” controls
  - Wheel motors

# Megatrend Urbanization

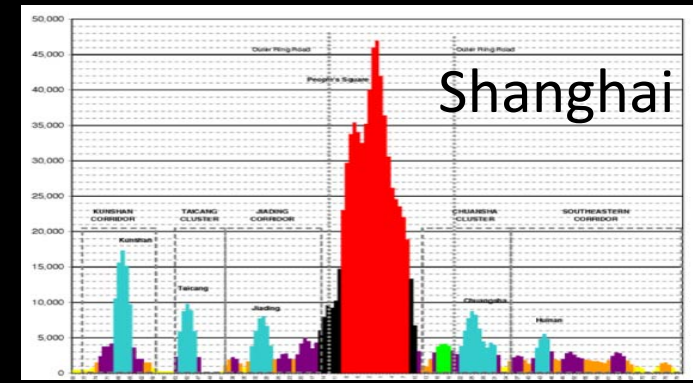
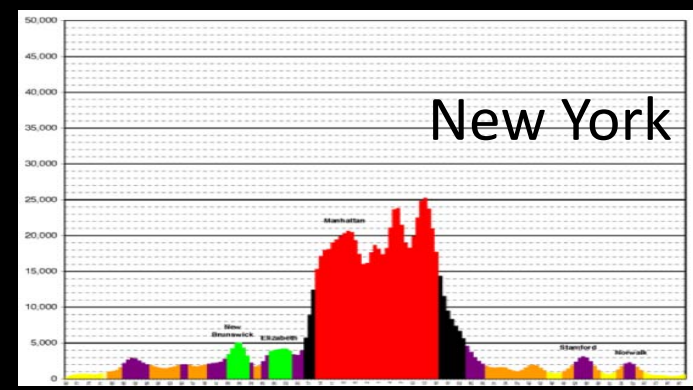
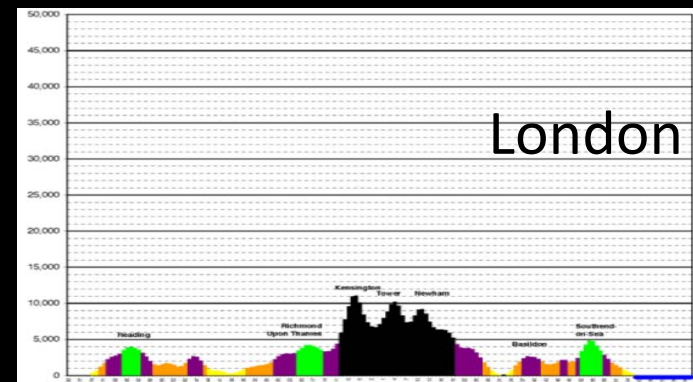


# Developing Cities are the Most Densely Populated



Manhattan

Sao Paulo, Tokyo

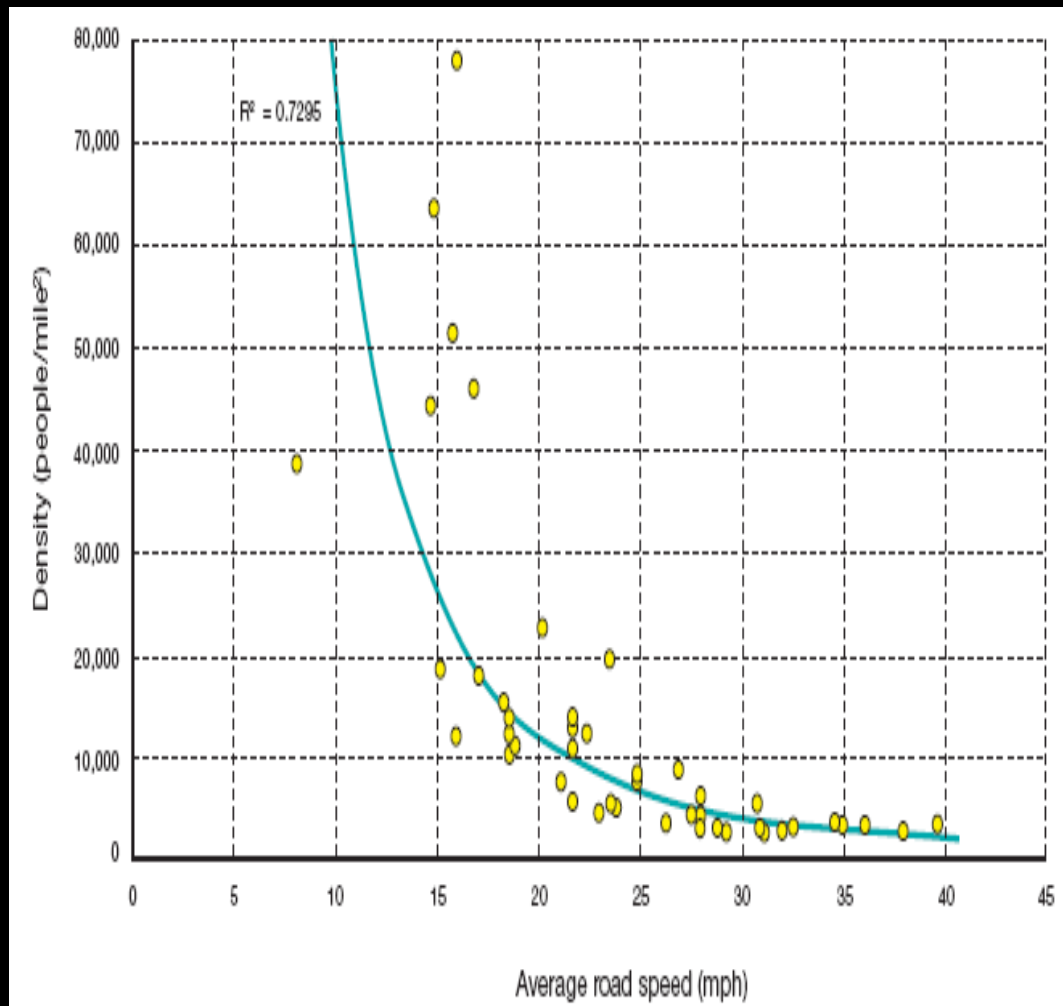


Population density (people/hectare)

100,000/  
sq.mile

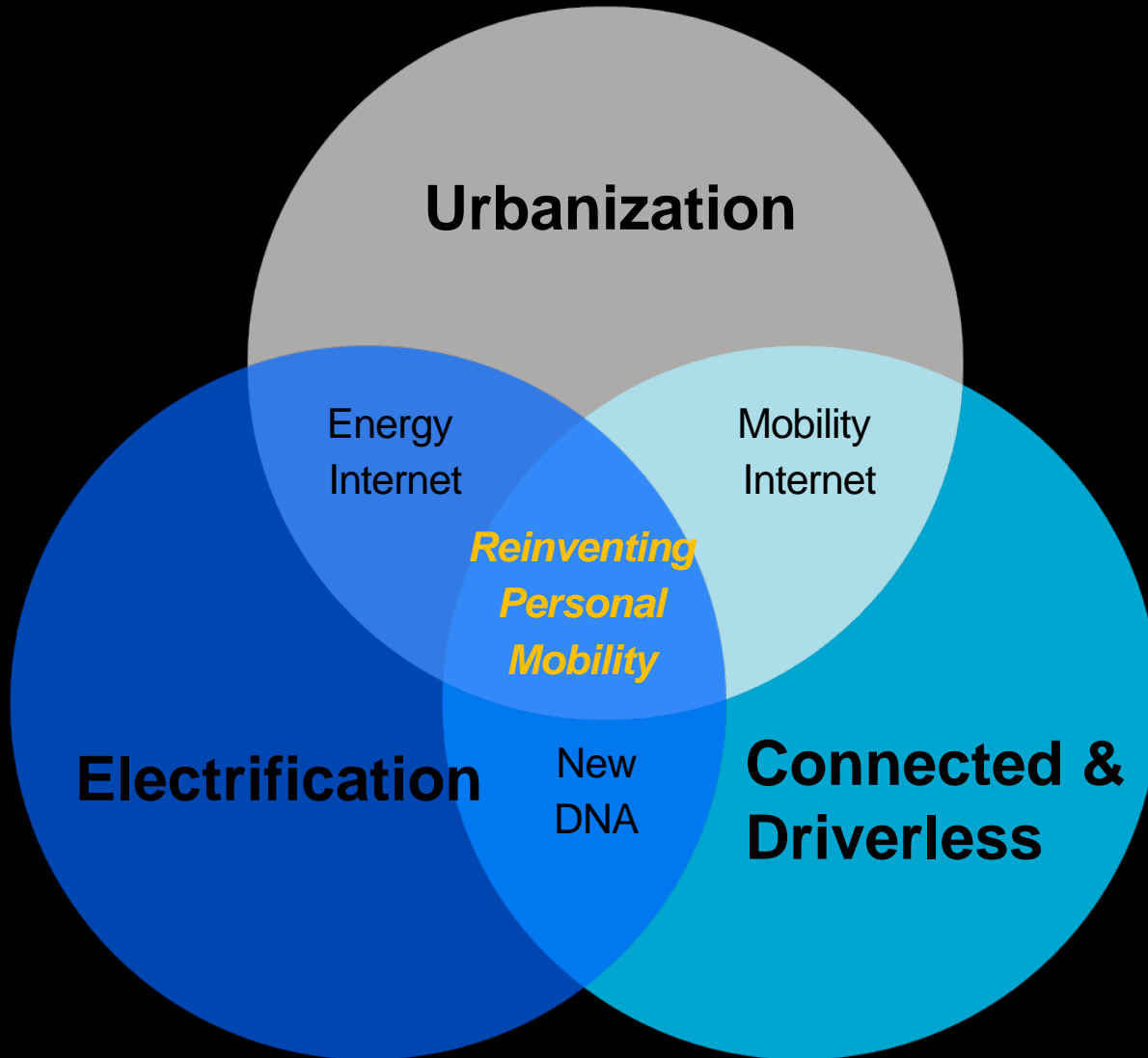
Source: Alain Bertaud (2002)

# Population Density and Traffic Speed



Source: data from Jeffrey R. Newman, Felix B. Laube (eds) (2002)

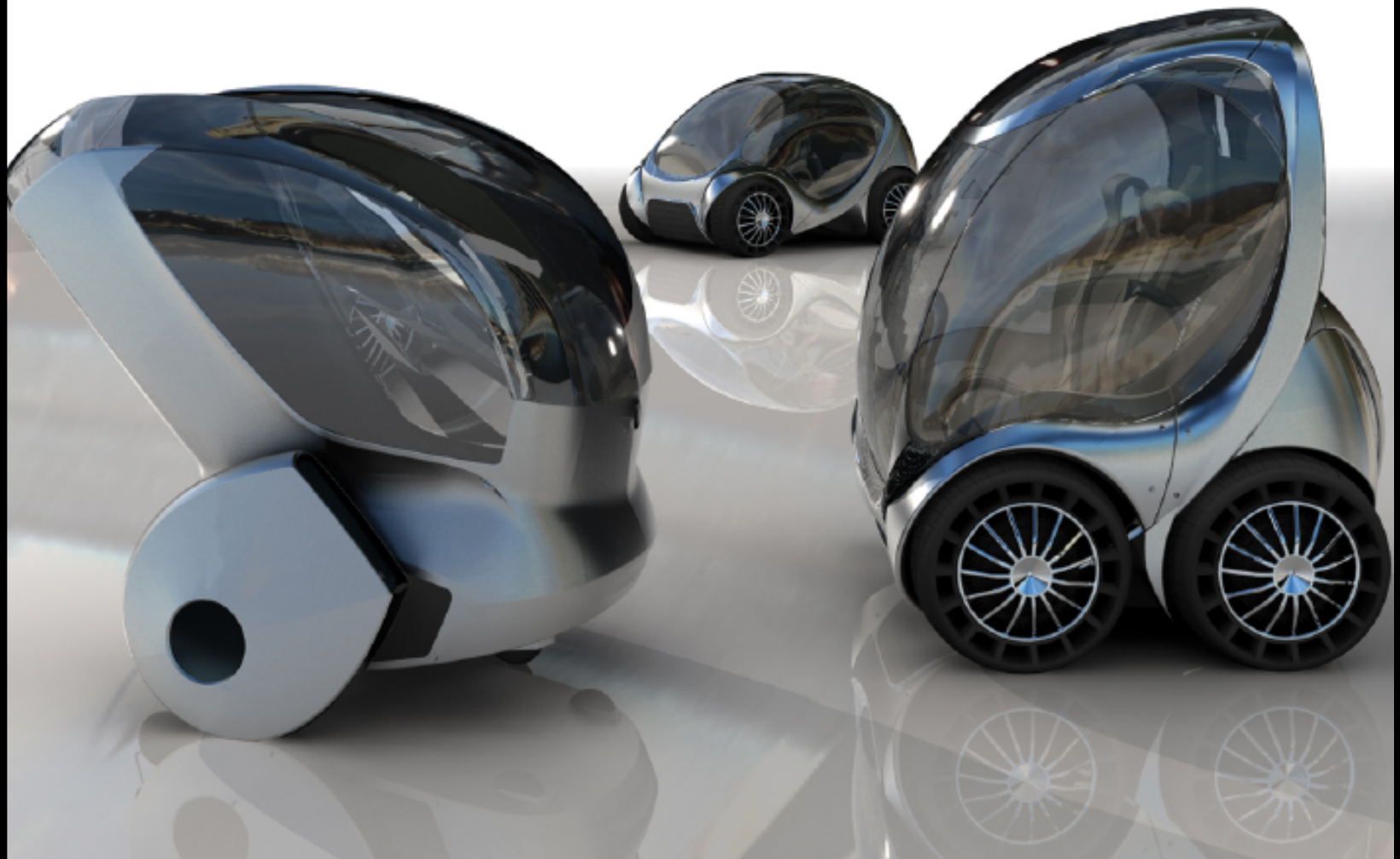
# Reinventing Personal Mobility



# Reinventing the Automobile

Personal Urban Mobility for the 21st Century

William J. Mitchell, Christopher E. Borroni-Bird, and Lawrence D. Burns



15 X

10 X

5 X

5 X

0 X

# Additional Opportunity

Driverless Vehicles

+

The “Mobility Internet”

+

Specific Purpose Designs

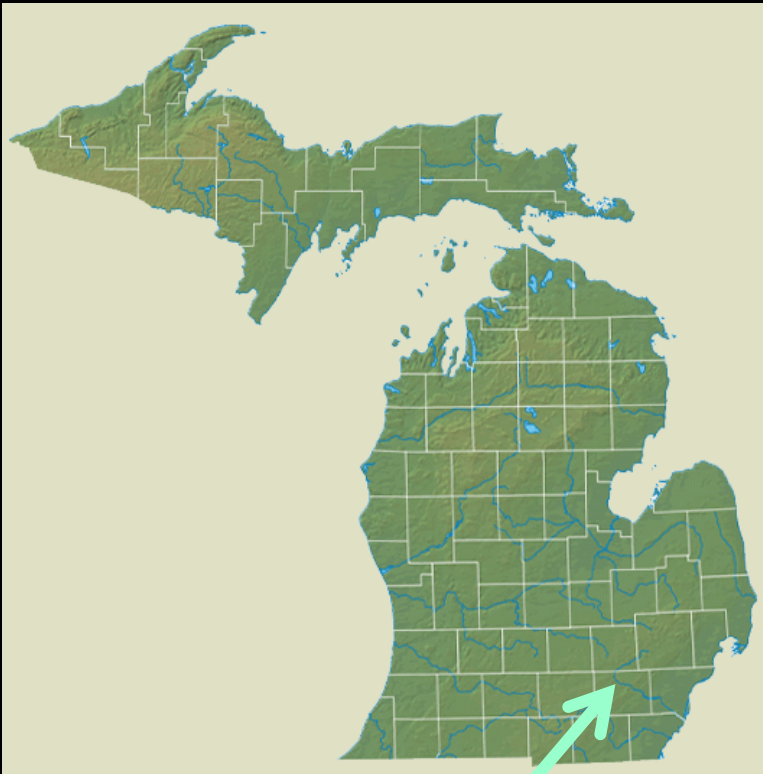
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***Shared Vehicles***

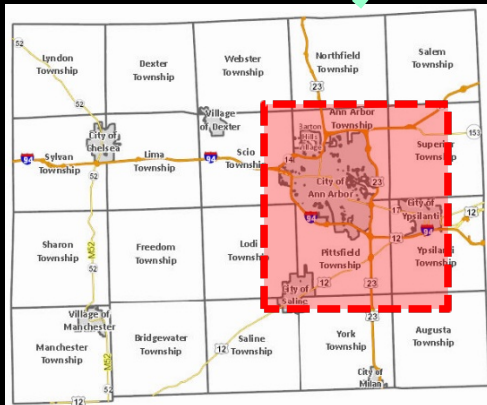
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Accessibility Freedom of Automobiles at  
Dramatically Lower Consumer and Societal Cost

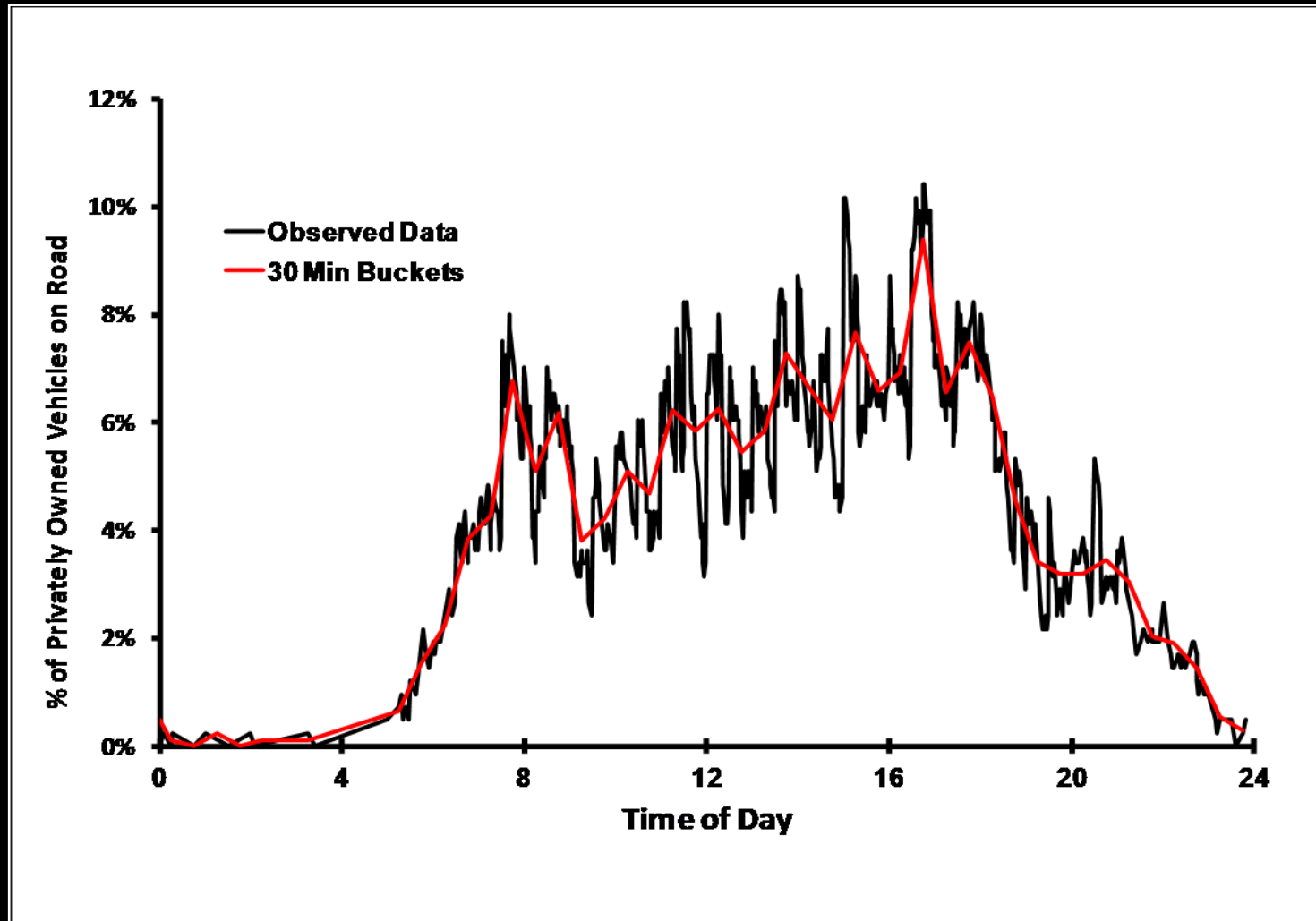
# Example: Ann Arbor, Michigan USA



- 285,000 people
- 130 square miles
- 200,000 personally owned vehicles
- 740,000 trips per day (3.7 trips/vehicle)
- Average trip
  - 8.2 miles
  - 16.3 min
  - 30 mph
  - 1.5 people
- Vehicles used an average of 60 minutes/day (4%)

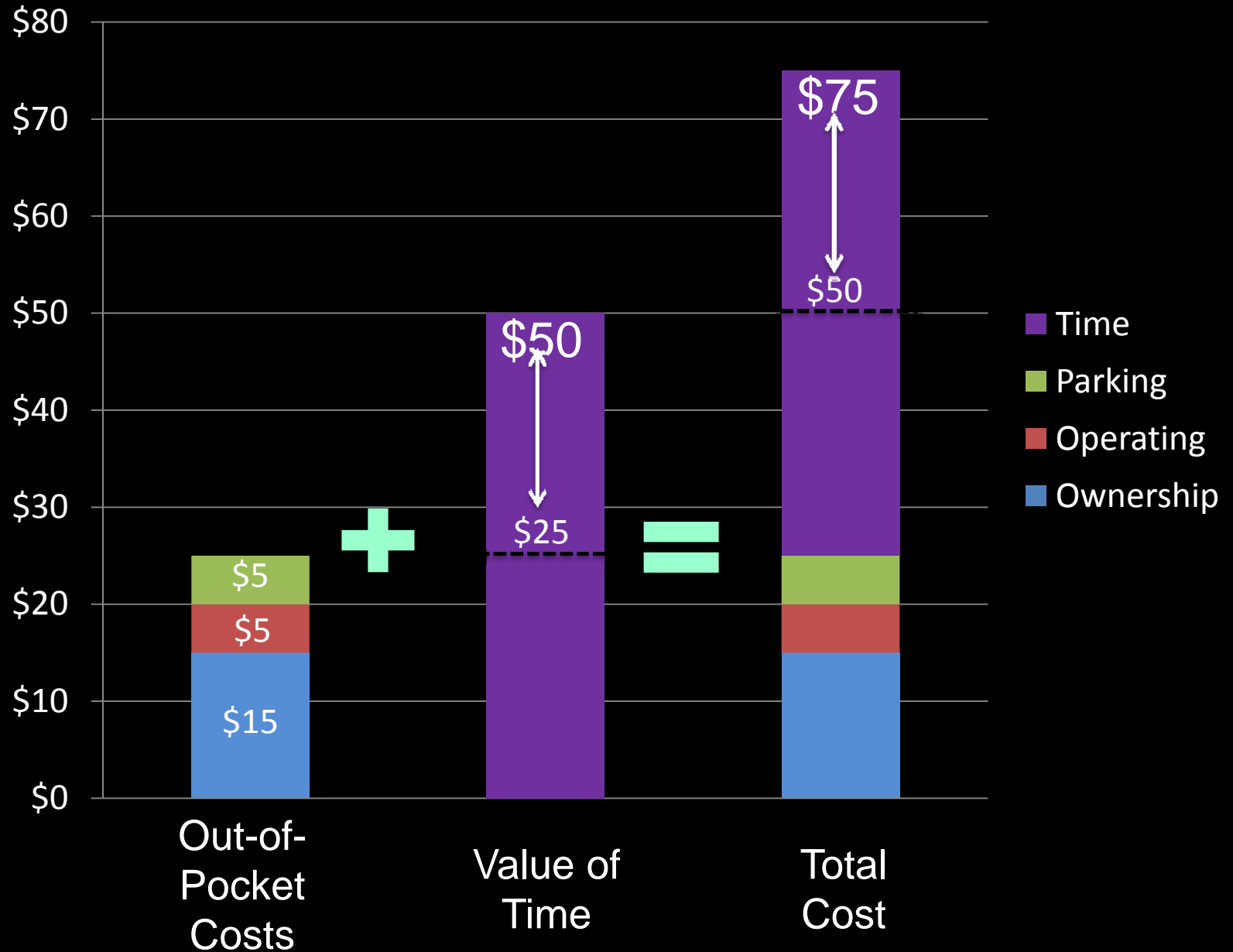


# Distribution of Vehicle Trips During Day



- *85% of trips start or end between 700 and 1900*
- *10% of vehicles on road during peak at 1700*

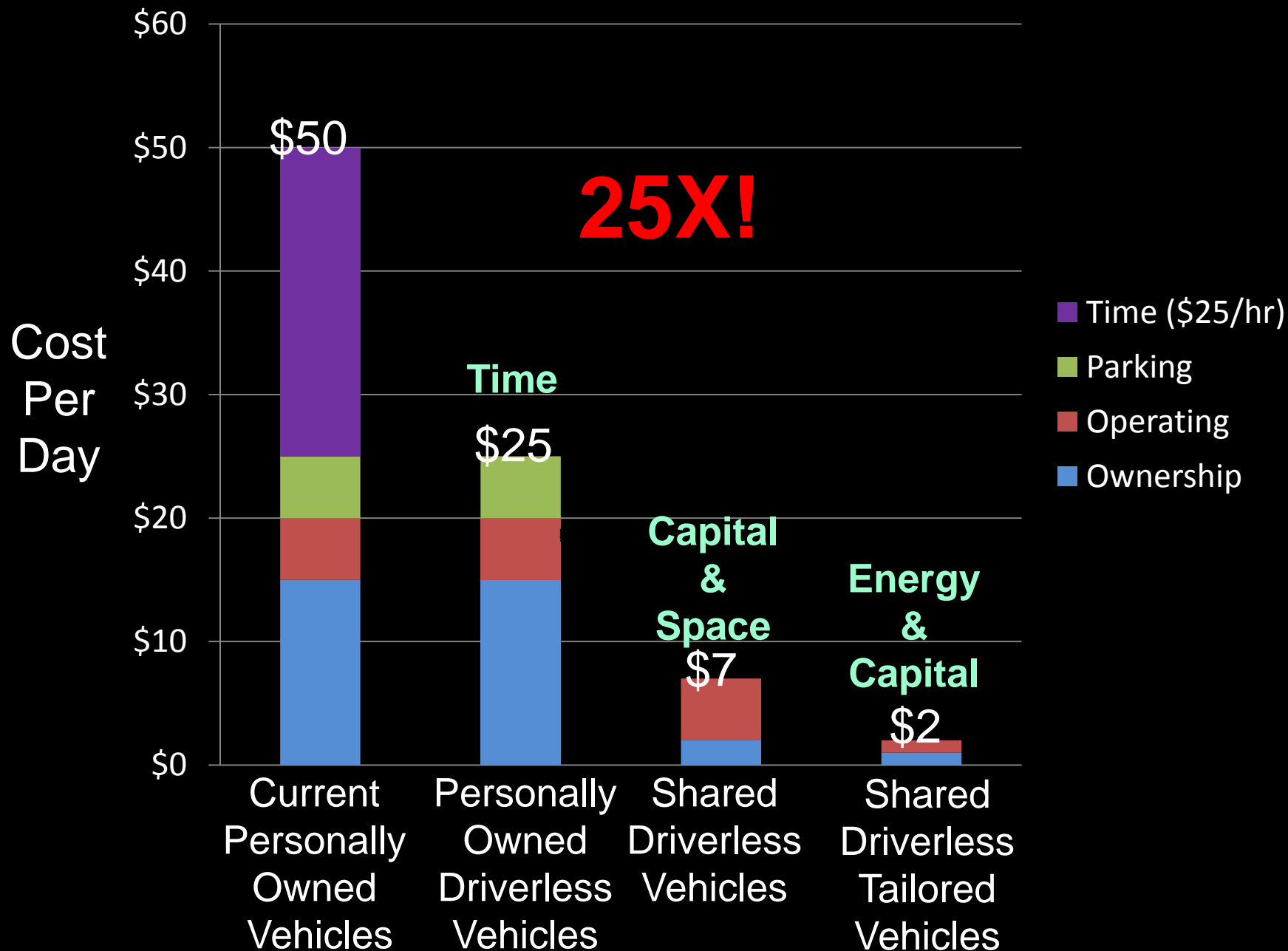
# Cost Per Day to Own and Drive a Car (Ann Arbor)



# What Might be Possible?

- Shared fleets of driverless, coordinated, specific purpose vehicles
  - 1 to 2 passenger for personal activities
  - 4 to 6 passenger for family/group activities
  - Light duty trucks for loads
- The right vehicle arrives at your origin when you need it and takes you to your destination while you use your time as desired ....  
*undistracted by having to drive*
- Vehicle then goes to the best next location to serve someone else
- Fleets sized and coordinated to match accessibility freedom of personally owned vehicles
  - Same travel demand
  - Fewer vehicles ( “tailored”, highly utilized, minimal parking )
  - Minimized empty miles

# Potential Exists for Transformational Change



# Risks of Disruption

- Disrupted Industries
  - Photography
  - Media
  - Entertainment
  - Computer
  - Telecom
  - Television
  - Pharmaceutical
- Incumbents Rarely Do Well When Industries Disrupt
- Transportation and Energy Industries Are Ripe For Disruption

# Recommendation

- Innovate
  - Technology, systems and business models
  - “Do unto yourself before others do unto you”
- Place high priority on driverless vehicles and the “Mobility Internet”
  - Collaborate on codes and standards
  - Accelerate learning
    - Consumers
    - Integrated systems
- Proactively pursue sustainable mobility .....  
it is now within our grasp