The New Mobilities

Smart Planning for Emerging Transportation Technologies

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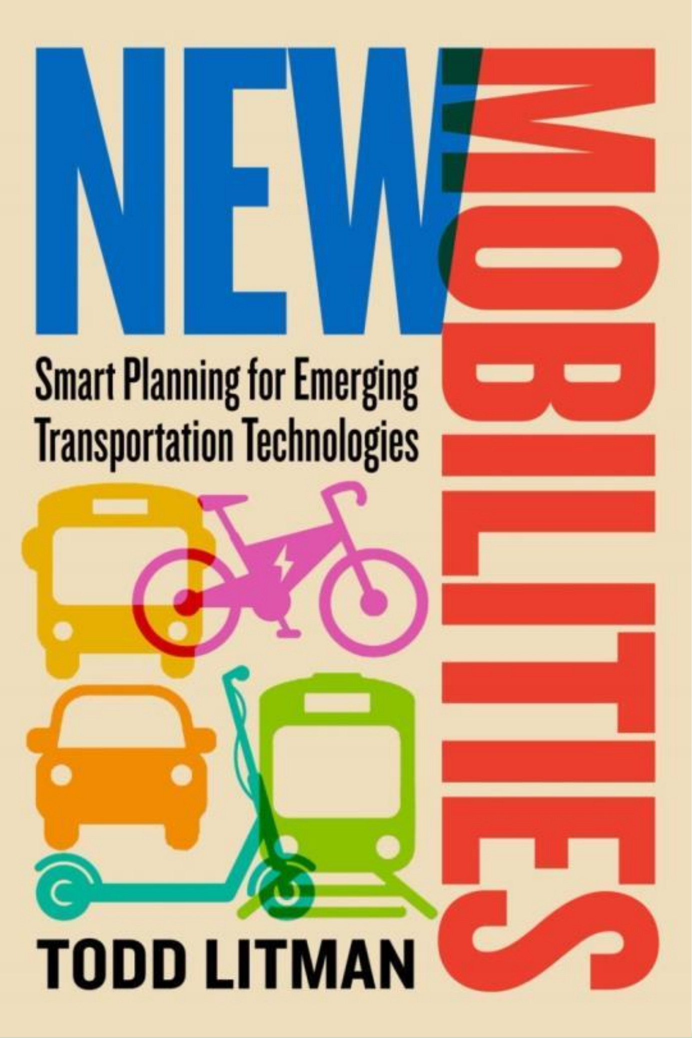
New Mobilities



New Mobilities: Smart Planning for Emerging Transportation Technologies

New Mobilities have tantalizing potential. They allow people to scoot, ride, and fly like never before. They can provide large and diverse benefits. However, they can also impose significant costs on users and communities.

Decision-makers need detailed information on their impacts.

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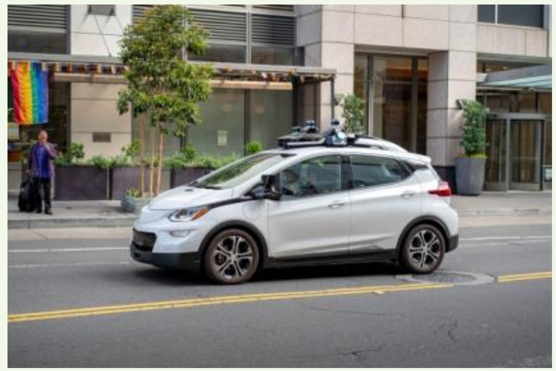
Previous Transportation Dreams

Previous transportation innovations seem exciting and beneficial. They are part of our collective dreams of a better future.

Transportation Futures

E-bikes



Autonomous Cars

Air Taxi

Transit Improvements

Mobility as a Service

Pneumatic Tube Transport

New Mobilities

A dozen emerging transportation technologies and services

1. **Active Travel and Micromobilities.** Walking, bicycling, and variations, including e-bikes and e-scooters.
2. **Vehicle Sharing.** Convenient and affordable bicycle, scooter, and car rentals.
3. **Ridehailing and Microtransit.** Mobility services for individuals and small groups.
4. **Electric Vehicles.** Battery-powered scooters, bikes, cars, trucks, and buses.
5. **Autonomous Vehicles.** Vehicles that can operate without a human driver.
6. **Public Transport Innovations.** Innovations that improve transit travel convenience, comfort, and speed.
7. **Mobility as a Service (MaaS).** Navigation and transport payment apps that integrate multiple modes.
8. **Telework.** Telecommunications that substitutes for physical travel.
9. **Tunnel Roads and Pneumatic Tube Transport.** Underground roads and high-speed tube transport.
10. **Aviation Innovation.** Air taxis, drones, and supersonic jets.
11. **Mobility Prioritization.** Incentives that favor higher-value trips and more efficient modes.
12. **Logistics Management.** Integrated freight delivery services.

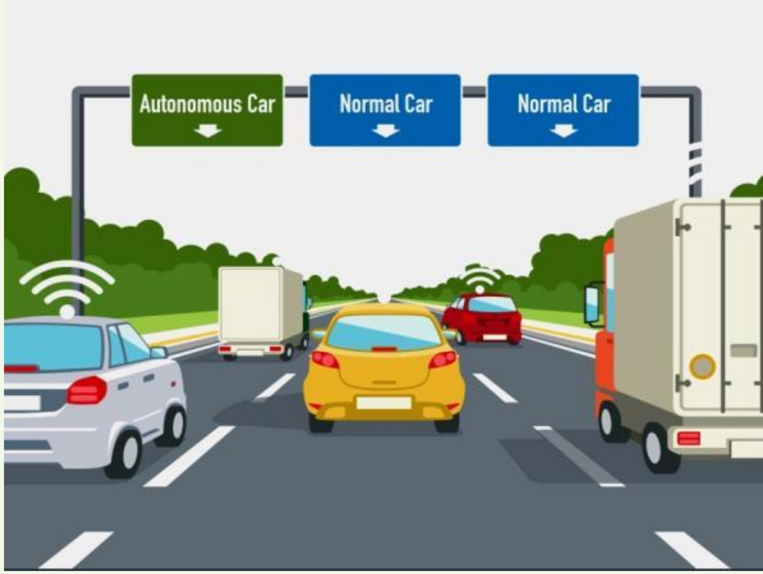
Questions for Communities

- How should we evaluate new transportation modes and services?
- What are their costs and benefits?
- Who is impacted?
- Who should bear the costs and risks?
- How should we integrate and optimize the New Mobilities into our transportation system?
- Which should be mandated, encouraged, regulated, restricted, or forbidden?

Example – Dedicated Lanes

Many potential benefits of autonomous vehicles depend on them having dedicated lanes where they can platoon (several vehicles driving close together at relatively high speeds).

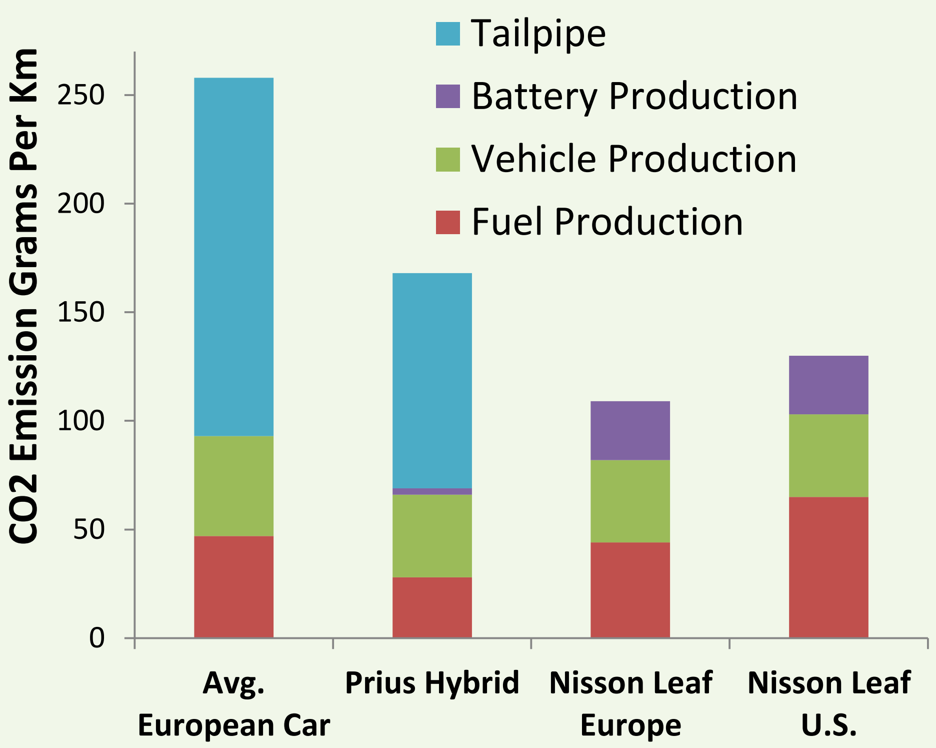
- At what point should highway agencies dedicate lanes to autonomous vehicles?
- What should users pay for this privilege? How should this be enforced?
- Who is liable if a platoon has a multi-vehicle crash?
- What is most efficient and fair?



Example – Electric Vehicle Benefits

Most transportation emission reduction plans subsidize electric vehicles. Since they have lower operating costs, EVs tend to be driven more annual miles, which increases traffic problems

- How much should communities subsidize electric vehicles compared with other emission reduction strategies?
- How can these subsidies be equitable?
- How should they prevent rebound effects?

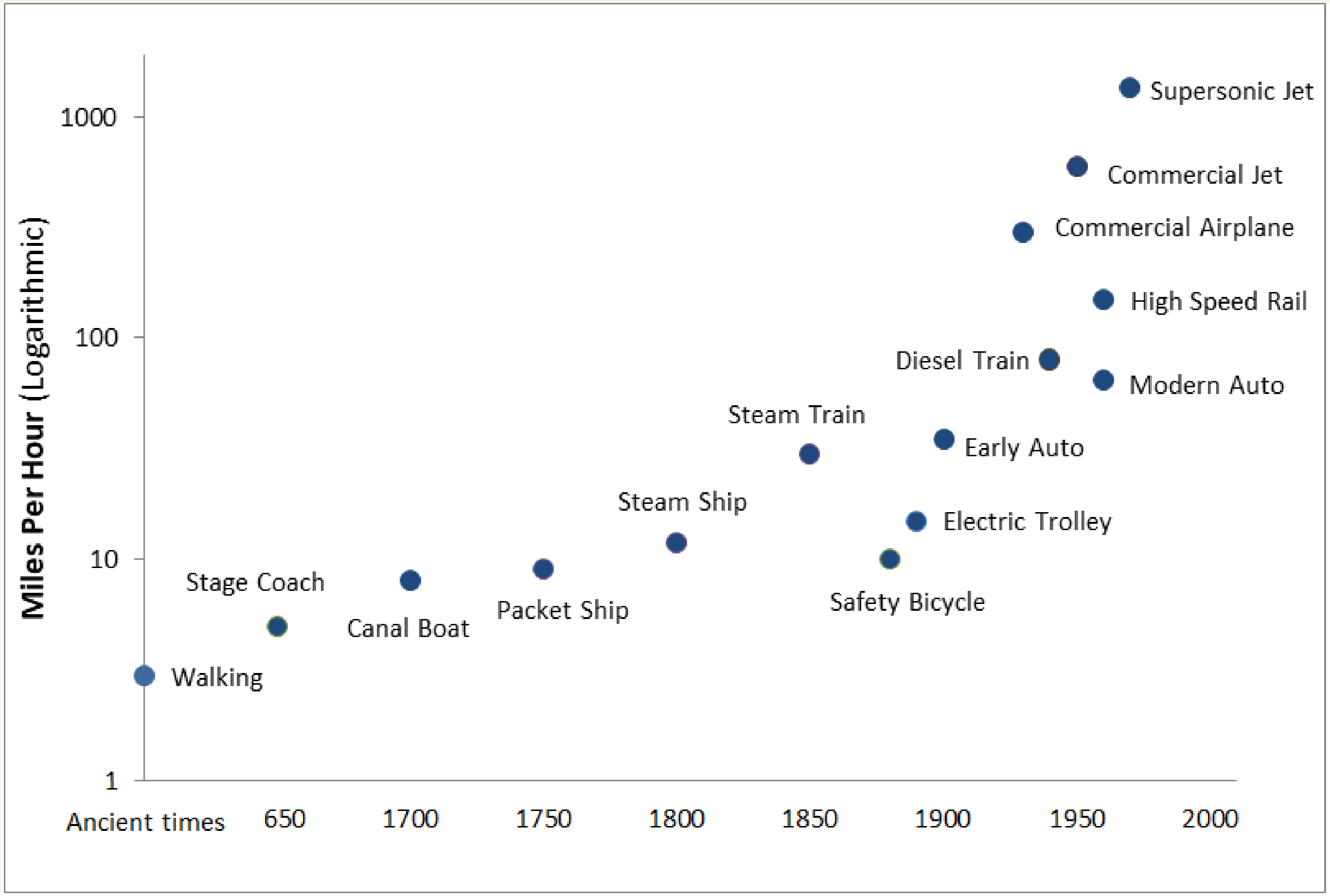


Electric vehicles typically reduce emissions 50-70% compared with a comparable fossil-fuel vehicle. Although this is good, it is inaccurate to call them "zero emission" vehicles.

In the Past, Newer Was Faster

For most of transportation history, newer modes were faster.

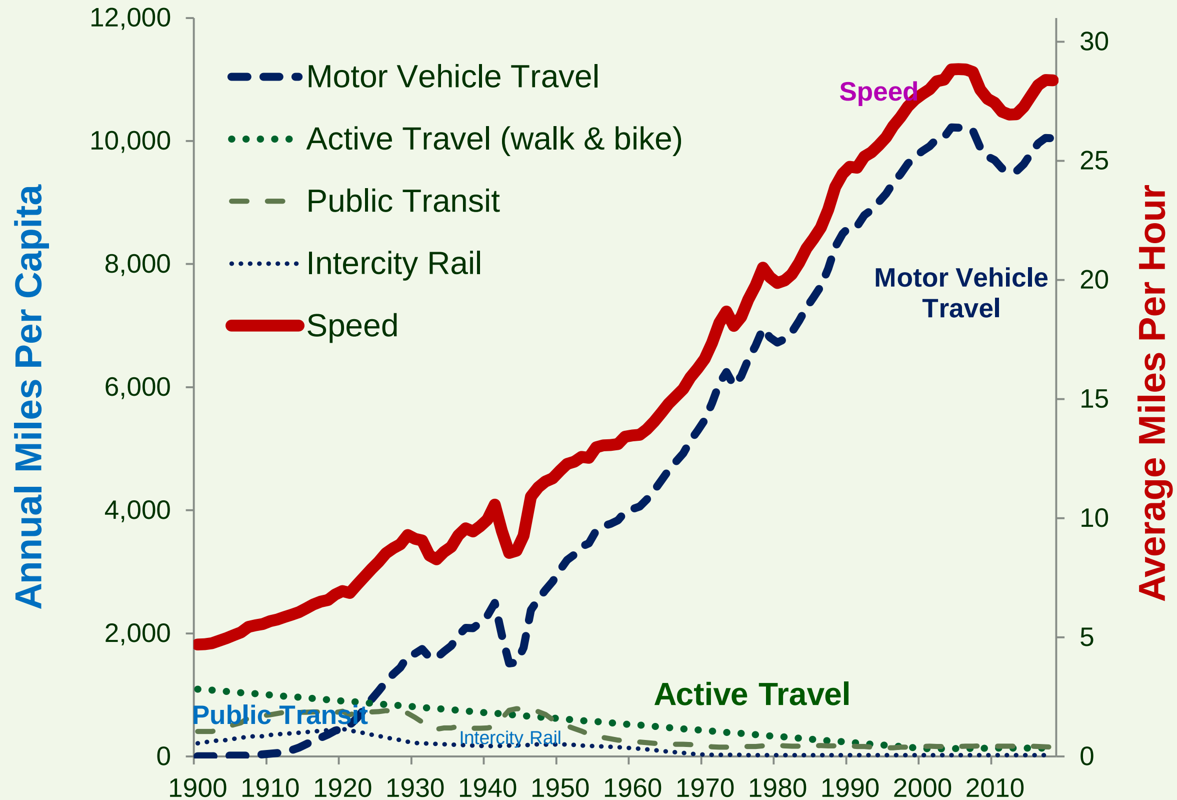
Note that this graph shows speed on a logarithmic scale so small increases in height indicate large increases in speed.



Travel Trends

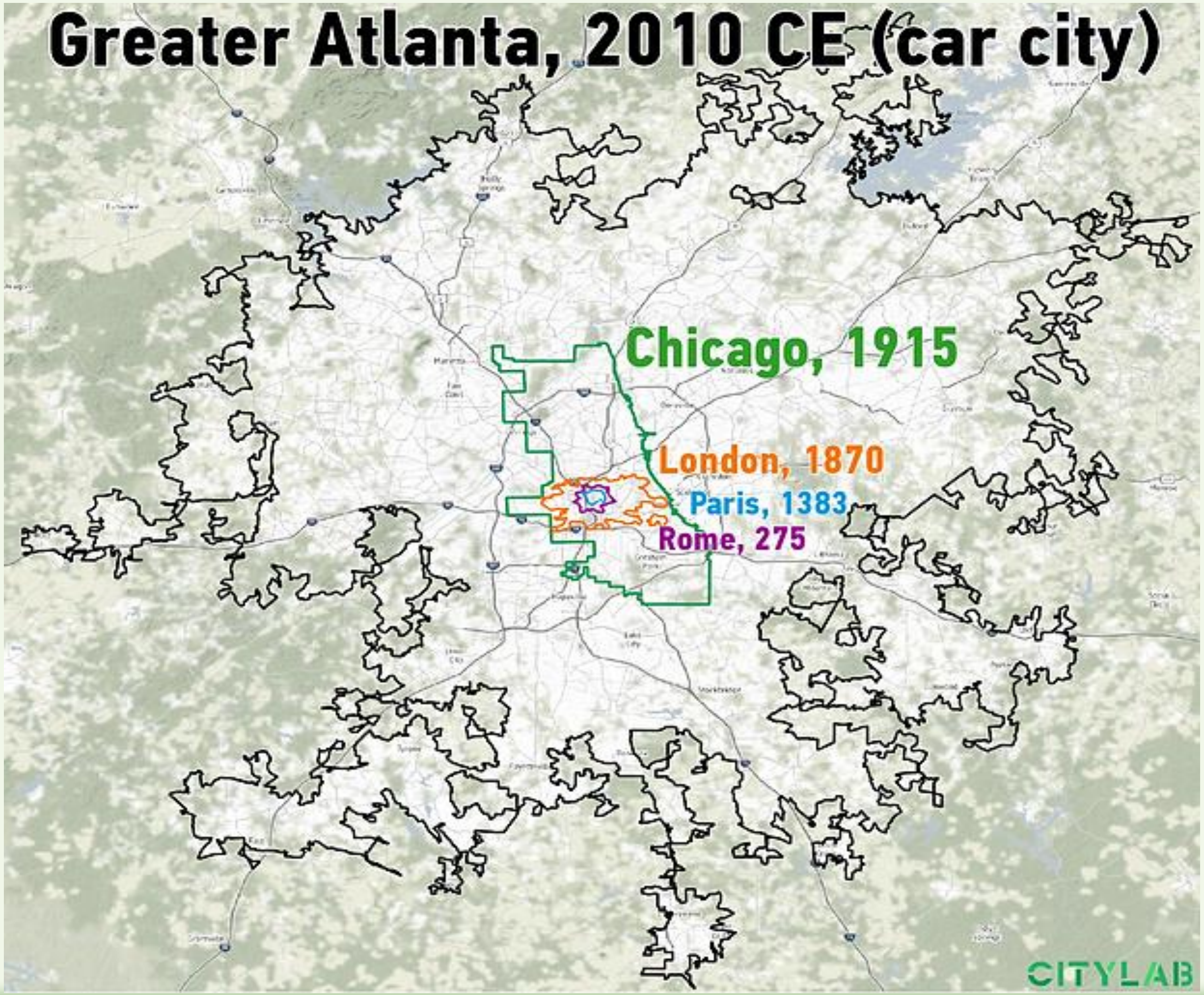
Before 1900 people relied primarily on walking, averaging about 1,000 annual miles, with occasional bicycle and rail trips.

Motor vehicle travel grew steadily during the Twentieth Century. It now averages about 10,000 annual miles per adult.



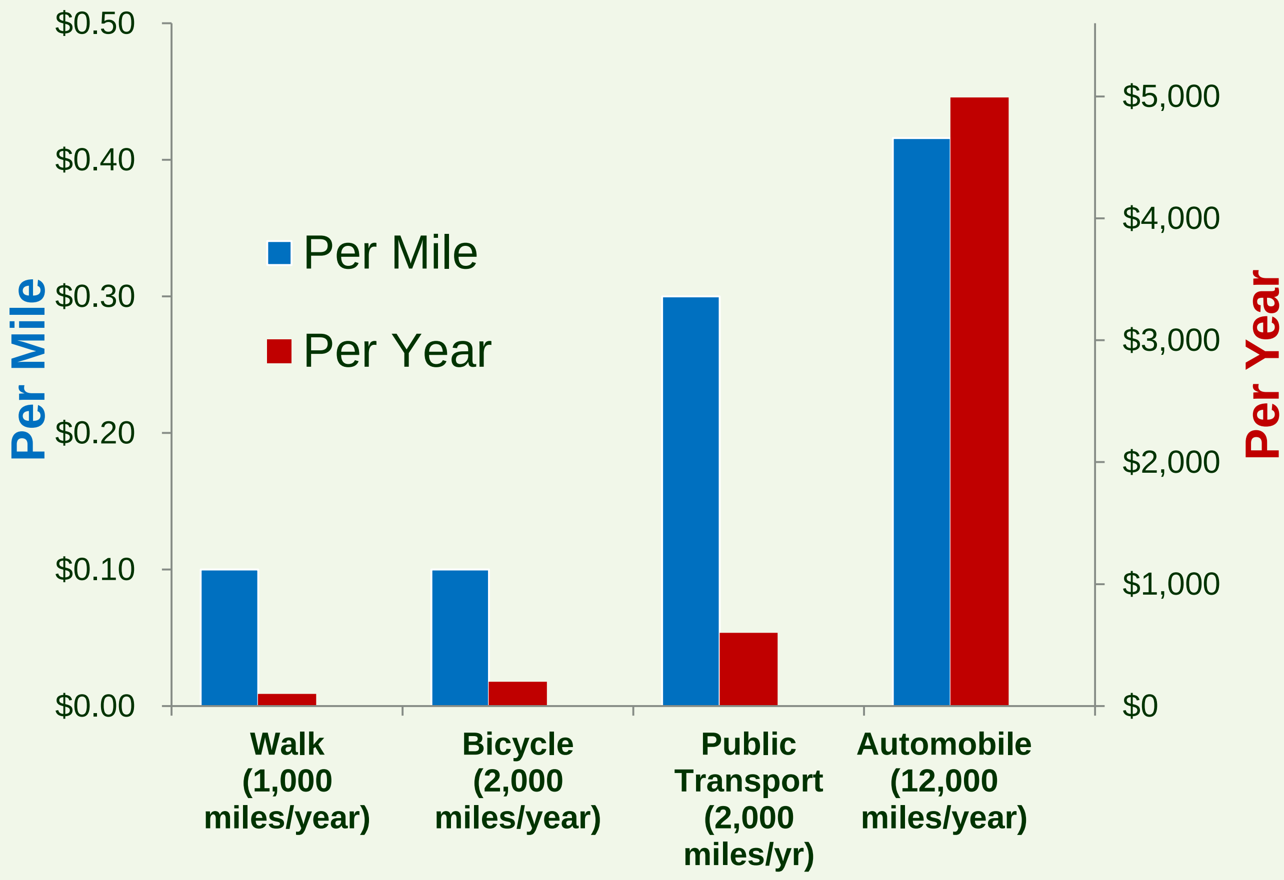
Automobile Travel Causes Sprawl

Ancient Rome and Paris were compact walking cities. London and Chicago expanded along rail lines, with walkable, transit-oriented neighborhoods. Greater Atlanta is a sprawled, automobile dependent city where it is difficult to live without a car.



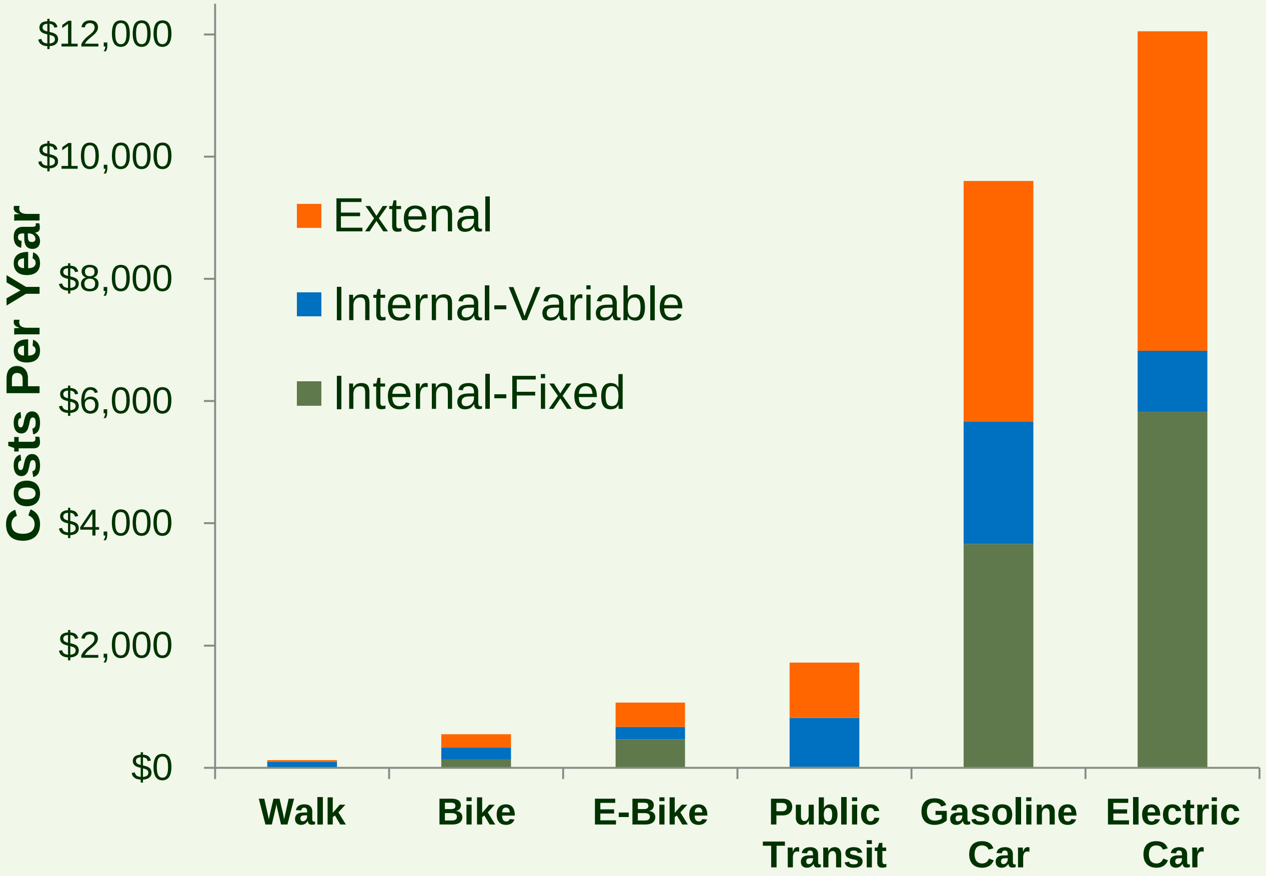
Typical User Costs Per Mile and Year

Automobile travel tends to be somewhat more costly per mile, and far more costly per year because automobile ownership increases annual mileage.



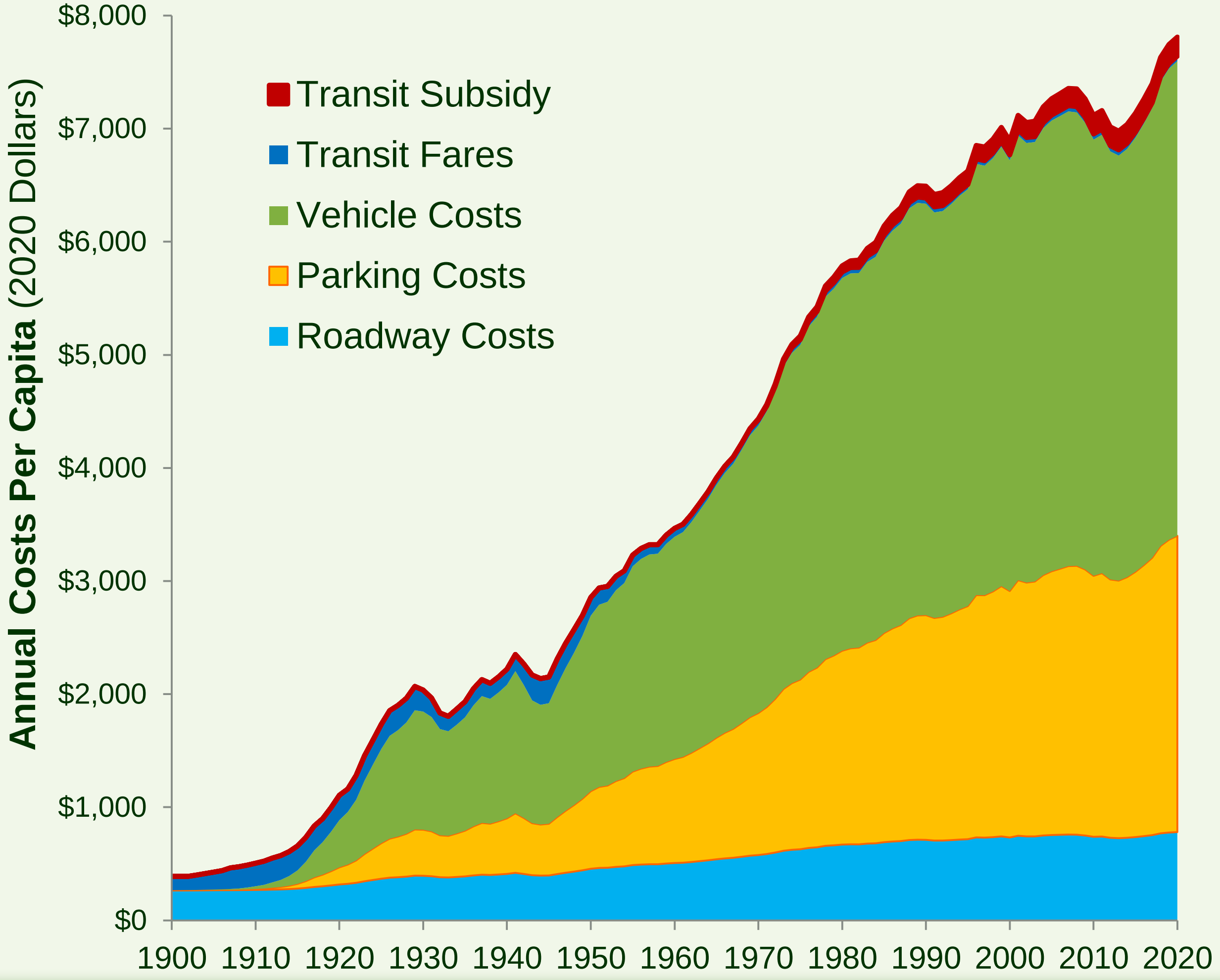
Costs and Subsidies

Walking, bicycling, e-bikes and public transit have much lower costs to users and communities than automobile travel.



Estimated Vehicle and Infrastructure Costs

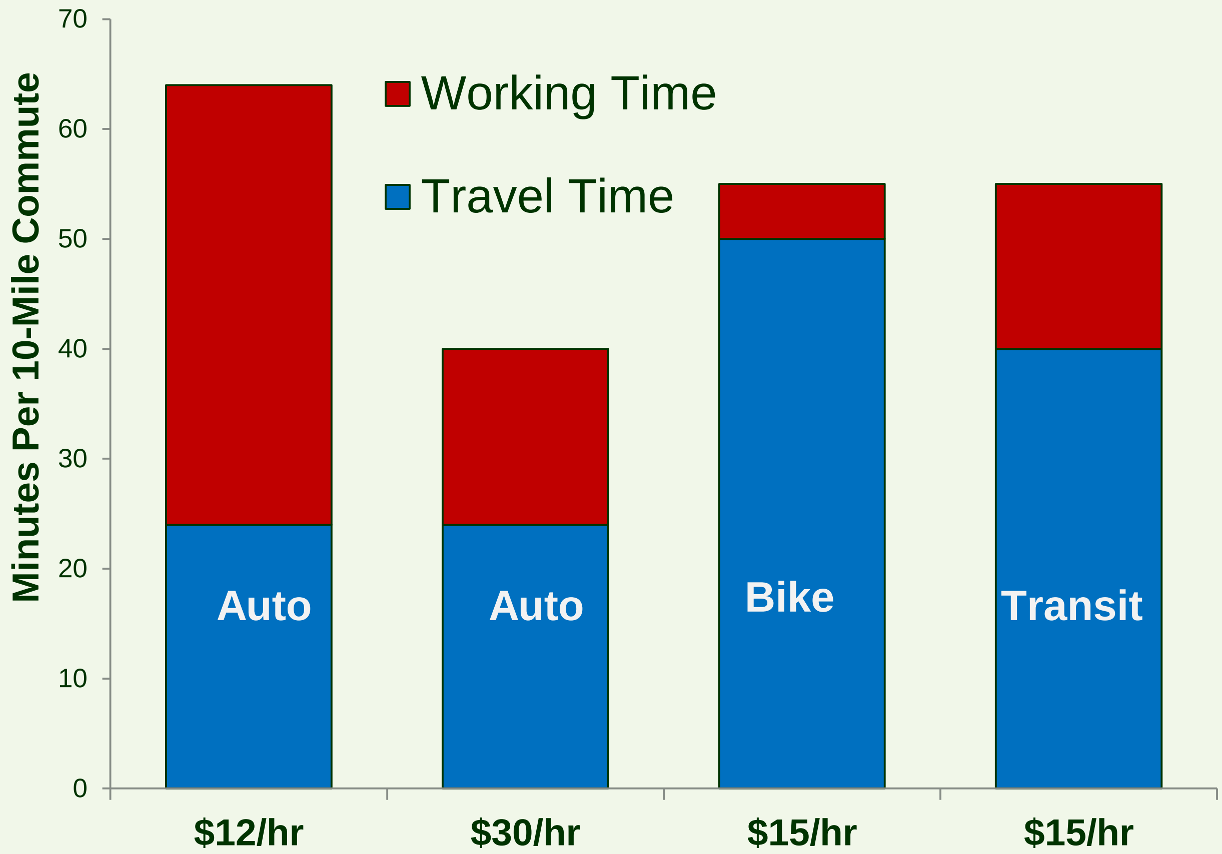
As automobile travel grew during the last 120 years, per capita vehicle, road and parking facility costs increased significantly.



Effective Commute Speeds

Effective speeds, measures time spent travelling plus time spent working for money to pay travel expenses.

Many lower-wage motorists spend more time earning money to pay their travel expenses than they spend travelling. Bicycling and transit are generally faster than driving overall.



A New Planning Paradigm

	Old Paradigm	New Paradigm
Definition of Transportation	Mobility (physical travel), mainly automobile travel.	Accessibility (people's overall ability to reach services and activities).
Modes considered	Mainly automobile	Multi-modal: Walking, cycling, public transport, automobile, telework and delivery services.
Objectives	Congestion reduction; roadway cost savings; vehicle cost savings; and reduced crash and emission rates per vehicle-kilometer.	Congestion reduction; road and parking savings; consumer savings and affordability; accessibility for non-drivers; safety and security; energy conservation and emission reductions; public fitness and health; efficient land use (reduced sprawl).
Impacts considered	Travel speeds and delay, vehicle operating costs and fares, crash and emission rates.	Various economic, social and environmental impacts, including indirect impacts.
Favored improvements	Roadway capacity expansion.	Improve transport options (walking, cycling, public transit, etc.). Transportation demand management. More accessible land development.
Performance indicators	Vehicle traffic speeds, roadway Level-of-Service (LOS), distance-based crash and emission rates.	Quality of accessibility for various groups. Multi-modal LOS. Various economic, social and environmental impacts.

Evaluation

Evaluation Factor	Summary
Current status	Available
User experience	Fun! Sometimes frightening
Travel impacts	Can significantly reduce automobile travel.
Travel speeds and time costs	Is a slow mode, but has low travel time unit costs.
User costs and affordability	Very affordable.
Public infrastructure costs	Generally very low.
Congestion costs imposed on others	Generally imposed less congestion than auto travel.
Crash risk	Users bear risks, but impose minimal risk on others.
Social equity objectives	Very positive. Is often used by disadvantaged people.
Resource consumption	Very resource efficient.
Pollution emissions	Little or no pollution.
Public fitness and health	Excellent! Tends to be the healthiest mode.
Contagion risk	Minimal. Much lower than enclosed modes.
Effects on strategic planning goals	Generally very good. Encourages compact development.
Roles	Many roles in an efficient and equitable transport system

Micromobility

	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
Center column	Y	Y	Y	Possible	N	N
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing[2]	N	N	N	Y	N	Possible

Vehicle Sharing

Taxi, Ridehailing and Micro-Transit

Taxi

Ride Hailing
(taxi with electronic dispatching)

Micro Transit
(Shared ridehailing)

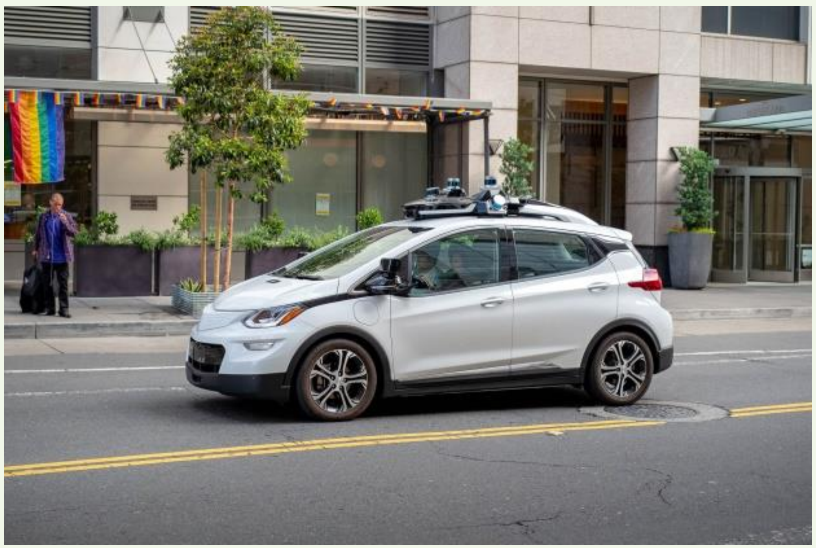
Currently, ridehailing tends to be somewhat less expensive and more convenient than conventional taxi services, but these advantages are likely to decline somewhat as taxi companies develop smartphone apps and ridehailing companies strive for profitability.

Public Transit Improvements

- More convenient – better navigation and payment systems, and real-time arrival information.
- Faster loading and operation.
- More frequent service
- More comfortable stations and vehicles, and amenities such as on-board internet.
- More affordable.
- Better integration with other modes.
- Better marketing, increased social status.

Electric and Autonomous Vehicles

Autonomous Trucks



Autonomous Cars

Autonomous Buses

Direct User Benefits

- Less stress.
- Cost savings compared with paid human drivers.
- More productivity during travel.
- Independent mobility for non-drivers.

Safety Impacts

Advocates predict that, because human error contributes to 90% of all traffic crashes, autonomous vehicles will reduce crashes by 90%.

This overlooks additional risks these technologies introduce.

Hardware and software failures. Complex electronic systems can fail. Self-driving vehicles will certainly have errors that cause crashes; the question is how frequently.

Malicious hacking. Self-driving technologies can be manipulated for amusement or crime.

Increased risk-taking. When travellers feel safer they tend to take additional risks, for example, reduced seatbelt use and less caution by other road users.

Platooning risks. Many potential benefits, such as reduced congestion and pollution emissions, require platooning. This can introduce new risks.

Increased total vehicle travel. Autonomous driving may increase total vehicle travel and therefore crashes.

Traffic Congestion Impacts

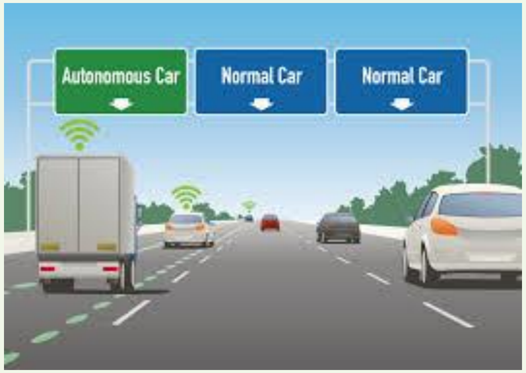
Autonomous driving may increase traffic congestion:

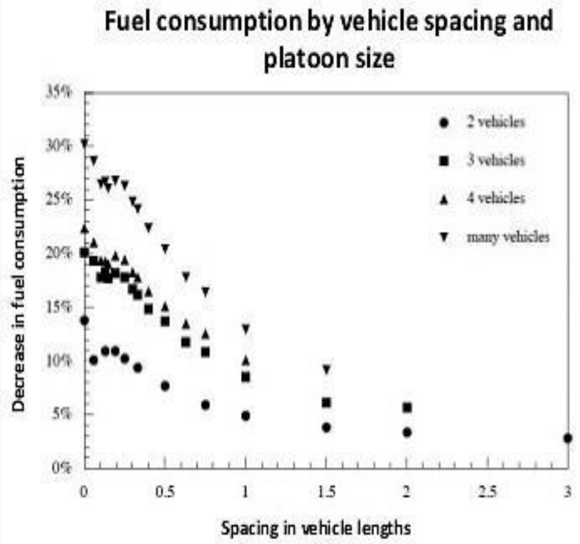
- Increases total vehicle travel.
- It is often cheaper to drive on public roads than pay for urban parking.
- May reduce public transit services.

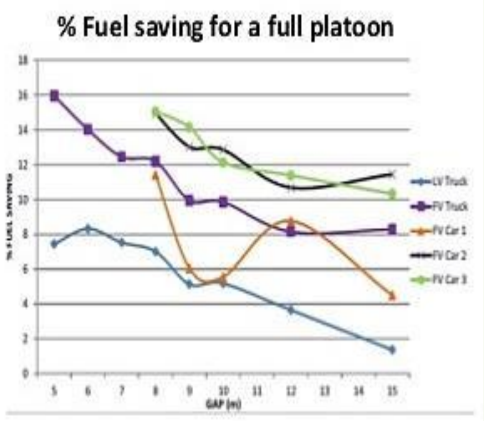
Bus **Human-Driven Cars** **Self-Driving Cars**

Infrastructure Requirements

- Many community benefits, such as reducing congestion and pollution, and improved mobility for non-drivers, require level 4-5 vehicles to become reliable and affordable.
- Reduced traffic congestion, energy consumption and pollution emissions require *platooning*, with vehicles travelling a few meters apart on dedicated highway lanes.







The above graph is based on measurements performed on a demonstrator system consisting of five vehicles: a lead truck (LV), a following truck (FV), and three following cars.

Owned Versus Shared Vehicles

Many projected benefits depend on vehicle sharing, but motorists have reasons to own their cars:

- **Convenience.** Motorists often keep items in their vehicles, such as car seats, tools, and other supplies.
- **Response speed**. In suburban and rural areas, taxi response can be slow and unreliable.
- **Costs.** Vehicle sharing is generally only cost effective for motorists who drive less than about 6,000 annual miles. Most higher annual mileage drivers will own their cars.
- **Cleaning and vandalism.** Autonomous taxis will lack privacy and comfort features.
- **Status.** Many drivers are proud of their skills and vehicles, and so may prefer to own and drive personal cars.

Once the novelty wears off, autonomous taxies will probably seem tedious and inferior, like elevator or economy air travel.

Equipment Costs

- Requires high-quality and redundant sensors, computers, controls, plus subscriptions to high-quality maps and specialized maintenance.

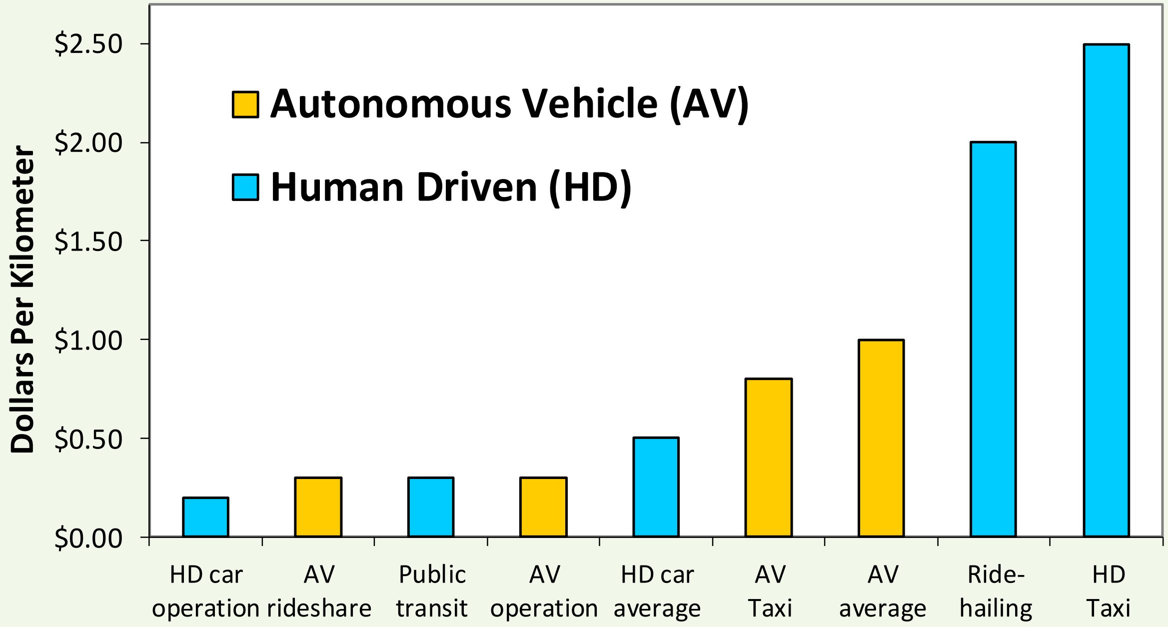
- This will add several thousand dollars to vehicle purchase prices, plus a hundreds of dollars in annual maintenance and service costs, probably increasing annual costs by $1,000 to $3,000.

- These incremental costs may be partly offset by fuel and insurance savings.

Typical Operating Costs

Some advocates predict that autonomous taxi fares will cost less than 20¢/km, but this ignores:

- Cleaning
- Maintenance
- Empty vehicle-kilometers
- Roadway costs
- Profits



Actual costs will probably be higher.

Autonomous vehicle travel will probably cost somewhat less than current human-operated taxis or ride-hailing services (Uber and Lyft), but more than current automobile travel.

Travel Impacts

Increases Vehicle Travel	Reduces Vehicle Travel
• Provides vehicle travel to non-drivers (people who are disabled, young or impaired). • Increased convenience and productivity increases travel. • Empty vehicle travel when dropping off or picking up passengers • Encourage sprawled development. • Reduces traffic congestion and vehicle operating costs.	• Convenient shared vehicle services reduce vehicle ownership and use. • Increases vehicle ownership and operating costs. • Self-driving buses improve transit services. • Reduced traffic risk and parking facilities make urban living more attractive. • Reduces some vehicle travel, such as cruising for parking.

Autonomous driving can increase vehicle travel in some ways and reduce it in others. Total impacts will depend on the public policies implemented in a jurisdiction. This will affect external costs including congestion, roadway subsidies, accident risk and pollution emissions.

Telework

Benefits

- Less commuting time and financial costs
- Reduced traffic congestion
- More time at home
- Flexible schedules

Problems

- Home equipment costs
- Isolation
- More sprawl and errand trips (often increases total vehicle travel)
- Unsuitable for many workers (particularly with low incomes)

Tunnel Roads and Pneumatic Tubes

Pneumatic Tube Transport

Tunnel Roads

Air Taxis, Delivery Drones & SST

Air Taxi

Super Sonic Jets

Delivery Drones

Mobility Prioritization

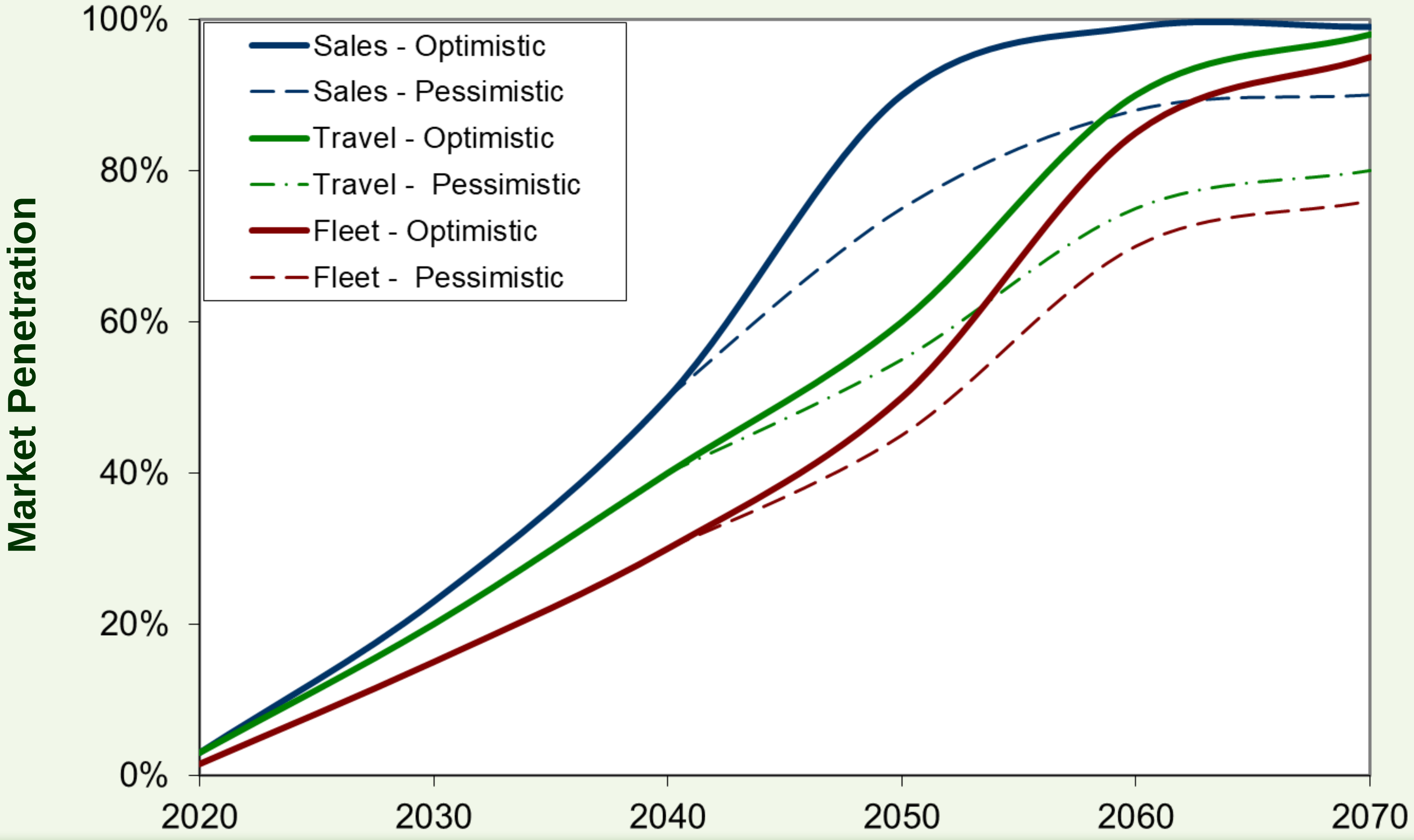
High-Occupancy Toll Lanes

Curb & Parking Management

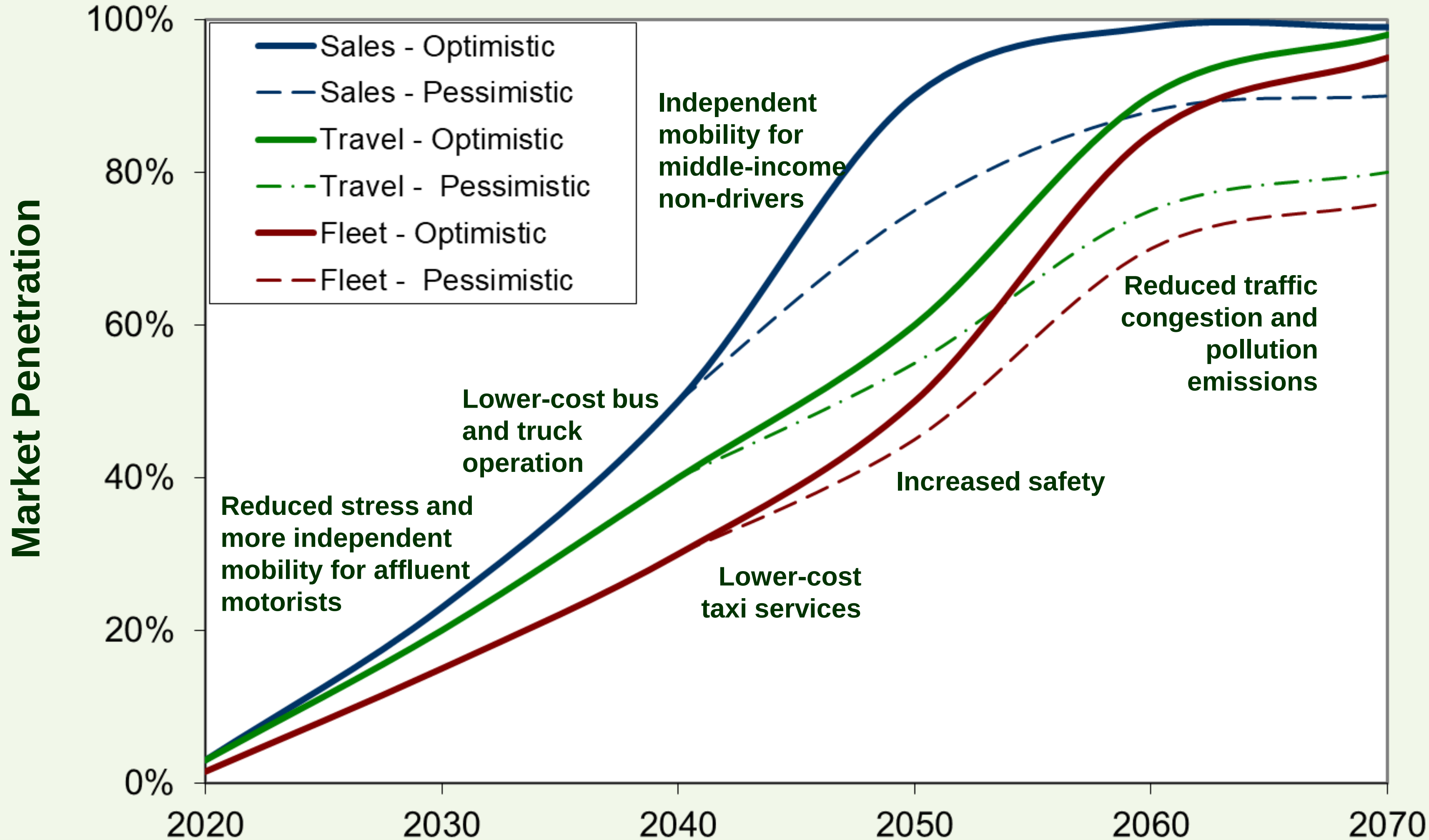
Mobility Priority	Curb/Parking Priority
1. Walking 2. Bicycling 3. Public transit 4. Commercial and service vehicles. 5. Shared automobiles (ridesharing) 6. Single-occupant vehicles and taxis 7. Mobile billboards and cruising to avoid parking fees	1. Passenger loading 2. Freight loading 3. Quick errands (less than 30 minutes) 4. Longer-term errands 5. Commuter 6. Residents 7. Long-term storage

Freight Logistics

Vehicle Innovations



Projected Benefits



Leverage Effects

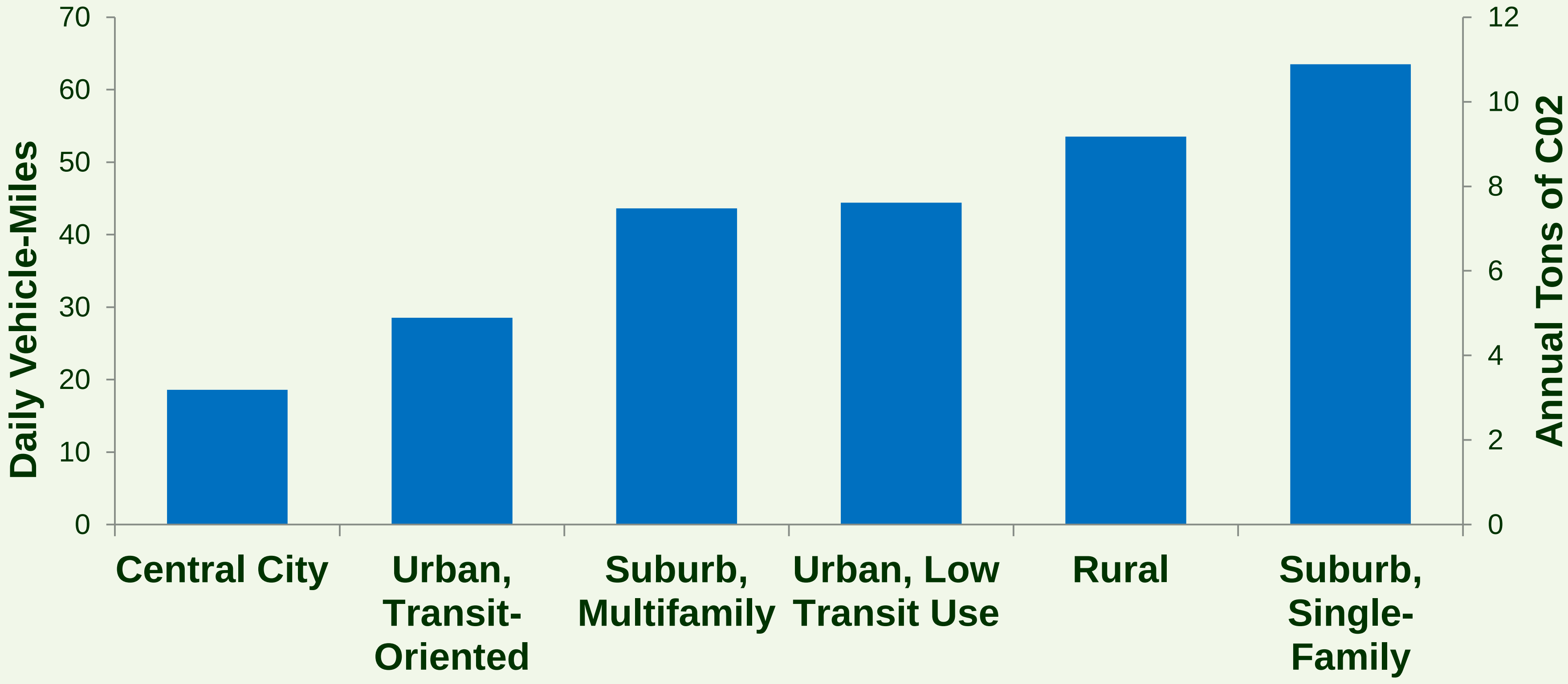
Improving non-auto modes can leverage additional vehicle travel reductions:

- *Reduced vehicle ownership.* As travel options improve, households reduce their vehicle ownership which reduces vehicle trips.
- *Shorter trips.* A shorter active trip often substitutes for longer motorized trips, such as when people walk or bike to a local store rather than driving to more distant shops.
- *Reduced chauffeuring.* Improving active travel conditions often allows non-drivers to travel independently, reducing their need to be chauffeured by motorists. Since chauffeuring trips often generate empty backhauls, a mile of walking or bicycling often reduces two vehicle-miles of travel.
- *More compact development*. Helps create more compact, multimodal neighborhoods.
- *Social norms.* As non-auto modes increase, so does their social status, further increasing non-auto modes.

Travel Impacts

Modes	Direct Impacts	Indirect Impacts
	Changes how people travel.	**Changes vehicle ownership and land use patterns.**
Active travel and Micro-mobilities	Moderate reduction. Reduces many short vehicle trips.	Large reduction. Supports transit and compact development.
Vehicle Sharing	Moderate reduction. Reduces automobile travel.	Moderate reduction. Can reduce car ownership.
Ridehailing and Micro-transit	Moderate increase due to deadheading.	Moderate reduction. Can educe car ownership
Electric Vehicles	Large increase due to reduced operating costs.	Small increase. Encourages sprawl.
Autonomous Vehicles	Large increase due to increased convenience.	Moderate increase. Encourages sprawl.
Public Transport Innovations	Moderate reduction. Directly reduces some driving.	Large reduction. Encourages compact development.
Mobility as a Service (Maas)	Small reduction. Helps reduces auto travel.	Small reduction. Helps reduce vehicle ownership.
Telework	Moderate reduction. Reduces some auto travel.	Moderate increase. Encourages sprawl.
Tunnel Roads & Pneumatic Tubes	Small increase. Tunnel roads encourage driving.	Moderate increase. Encourages sprawl.
Aviation Innovation	Moderate increase. Encourages air travel.	Small increase. Air taxis encourage sprawl.
Mobility Prioritization	Moderate reduction. Shifts auto to shared modes.	Moderate reduction. Encourages compact development.
Logistics Management	Moderate reduction. Reduces urban truck travel.	Moderate reduction. Encourages compact development.

Compact Development Reduces Emissions



Compact neighborhood households drive less, produce lower emissions, and impose lower transport costs. Allowing any that wants to locate in a compact, transit-oriented neighborhood achieves transport emission reduction goals. (Salon 2014)

Analysis Perspectives

	Potential Users	Industry	Community
Current status	✓	✓	✓
User experience	✓	✓	
Travel impacts	✓		✓
Travel speeds and time costs	✓		✓
User costs and affordability	✓		✓
Public infrastructure costs			✓
Congestion costs imposed on others			✓
Crash risk	✓		✓
Social equity objectives	✓		✓
Resource consumption			✓
Pollution emissions			✓
Public fitness and health	✓		✓
Contagion risk	✓		✓
Effects on strategic planning goals			✓
Roles	✓	✓	✓

Conclusions – Deployment

- Vehicle innovations tend to be implemented more slowly than other technological change due to high costs, strict safety requirements, and slow fleet turnover. Automobiles typically cost fifty times as much and last ten times as long as personal computers and mobile phones. Consumers seldom purchase new vehicles simply to obtain a new technology.
- Most vehicle innovations are initially costly and imperfect. It usually takes decades before they are common in the fleet.
- Predictions that autonomous electric taxis will soon be cheap and ubiquitous, and displace most private vehicle travel, are mostly by people with financial interests in the industry.

Conclusions – Benefits and Costs

- There is considerable uncertainty concerning New Mobilities' benefits, costs and travel impacts.
- Advocates often exaggerate net benefits by ignoring new costs and risks, rebound effects, and harms to other people.
- Some New Mobilities support, and others contradict, social equity goals.

Benefits Are Contingent

- Many potential benefits depend on how New Mobilities are implemented, regulated and priced.
- The most glamorous modes are not necessarily the most useful, beneficial or fun.
- Total benefits tend to be greatest for affordable, resource-efficient modes. Expensive, resource intensive modes tend to provide smaller benefits, greater costs and risks, and more inequity.

Conclusions – Planning Issues

- **Congestion and pollution.** If they stimulate more vehicle travel, New Mobilities can increase congestion and pollution.
- **Crashes.** New Mobilities may reduce some risks but increase others. Net safety benefits will depend on policies.
- **Affordable mobility for non-drivers.** Some New Mobilities provide affordable mobility for non-drivers. Those that increase automobile traffic and sprawl tend to harm non-drivers.
- **Parking.** Shifts from owned to shared vehicles can reduce parking demands. Parking policy reforms are needed to take advantage of these benefits.
- **Road and curb rights.** Cities should manage road space and curb rights for efficiency and fairness.

Policy Recommendations

- Test and regulate new technologies for safety and efficiency.
- Critically evaluate all impacts, including indirect and long-term effects on travel and development.
- Support active and micromodes for local trips and high capacity public transit on major travel corridors.
- Reduce parking requirements to take advantage of shared vehicles.
- Plan and price to prevent increased vehicle travel and sprawl.

Principles for Livable Cities

1. Plan our cities and their mobility together.
2. Prioritize people over vehicles.
3. Support shared and efficient use of vehicles, lanes, curbs, and land.
4. Engage with stakeholders.
5. Promote equity.
6. Lead the transition towards a zero-emission future and renewable energy.
7. Support fair user fees across all modes.
8. Aim for public benefits via open data.
9. Work towards integration and seamless connectivity.
10. In urban areas autonomous vehicles should only operate in shared fleets.

(www.sharedmobilityprinciples.org).

"Not So Fast: Better Speed Valuation for Transport Planning"

"Our World Accelerated: How 120 Years of Transportation Progress Affects our Lives and Communities"

"Autonomous Vehicle Implementation Predictions"

"The New Transportation Planning Paradigm"

"Transportation Cost and Benefit Analysis"

"Are VMT Reduction Targets Justified?"

"The Future Isn't What It Used To Be"

and more...

www.vtpi.org

Polls

1. How often do you encounter questions related to planning for New Mobilities?

Never

Seldom (less than monthly)

Sometimes (at least monthly)

Frequently (weekly)

2. How well do you feel prepared to plan for New Mobilities in your community?

Well. We have everything we need!

Moderate. We need better information concerning their development, benefits and costs, and social equity impacts.

Poor. We need to develop a new analysis framework and basic information.

Very poor. We don’t know where to start!

3. What new facilities, regulations, prices and programs should your community implement to prepare for New Mobilities?

Better bikeways in anticipation of more micromobilities (e-bikes, e-scooters, and their variants).

Public transit improvements and Mobility as a Service (MaaS).

HOV lanes, road pricing and curb regulations to favor shared modes (public transit, microtransit and ridesharing).

Special regulations and taxes on air taxi and delivery drone services.