# Autonomous Vehicles Deployment in Cities

(Discussion notes)

Prof. Jinhua Zhao

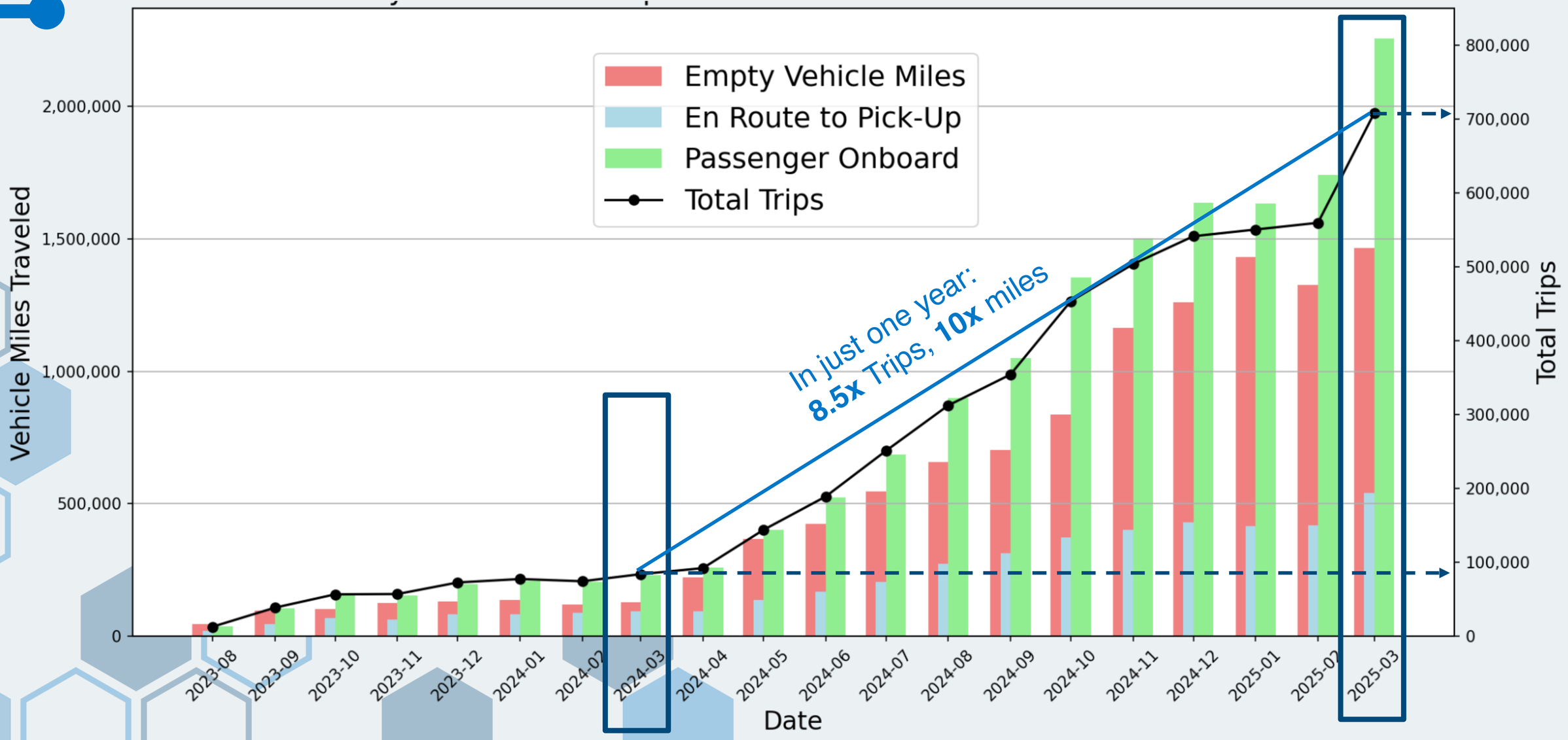
Automation in

- Public Transit
- Fleet Based Shared Service
- Privately Owned Cars

# 1. Measuring the right thing

# Growth of Waymo in San Francisco

Monthly vehicle miles traveled by **Waymo vehicles in commercial** service



$$\text{P to V Ratio (PVR)} = \frac{\text{Contribution to Society (Total Passenger Miles)}}{\text{Cost to Society (Total Vehicles Miles)}}$$

# In terms of PVR, Can AV be better than…?

1. Private owned vehicles
2. Uber/Lyft/Taxi
3. Dial-a-ride
4. Suburban buses
5. Urban buses
6. Subway

*Specific time*

*Specific location*

# Passenger to Vehicle Ratio

Waymo today

vs.

Waymo after 10x

# 2. Uber vs. Waymo

Incentivize Behavior

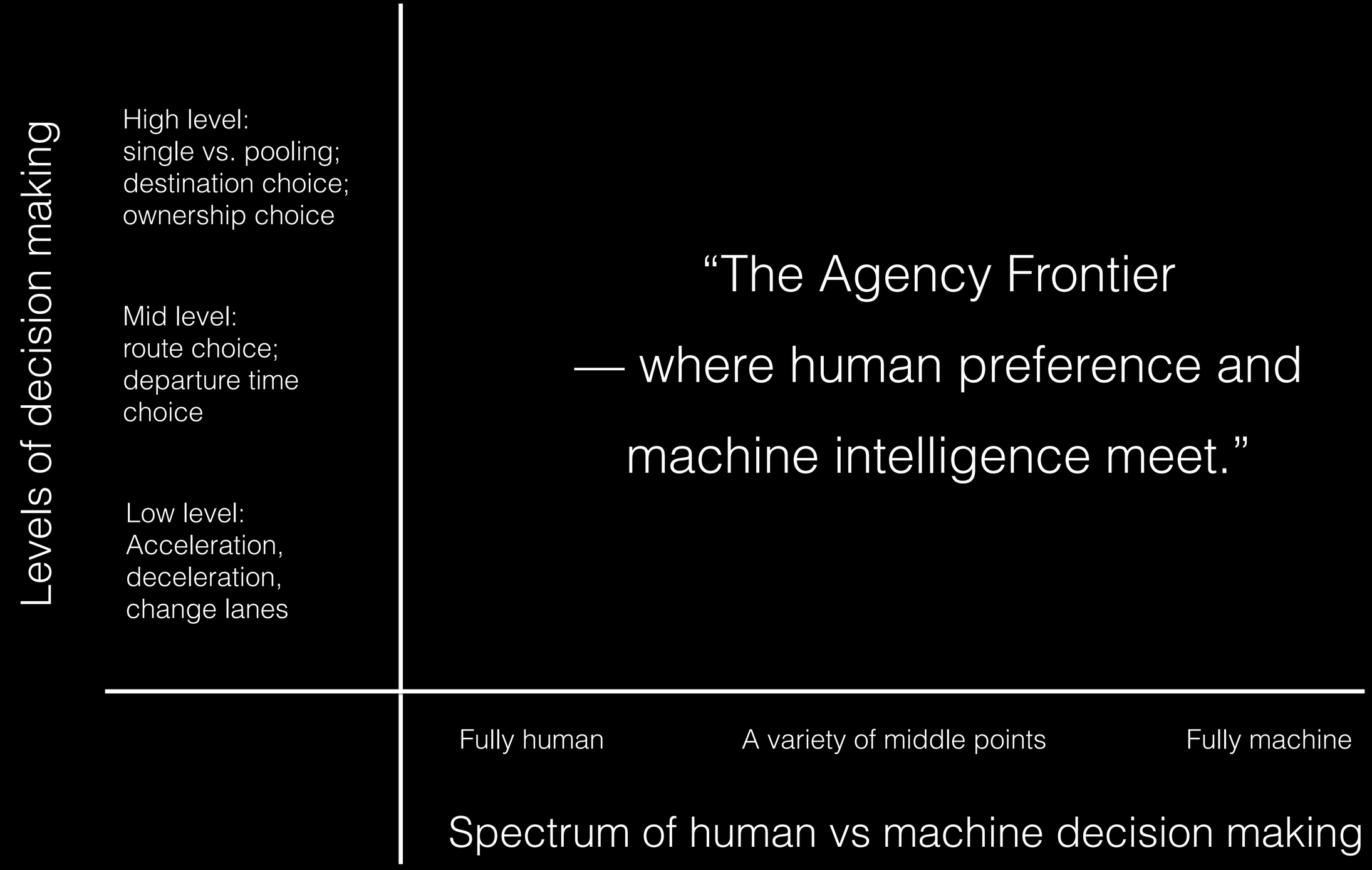
Dictate Behavior

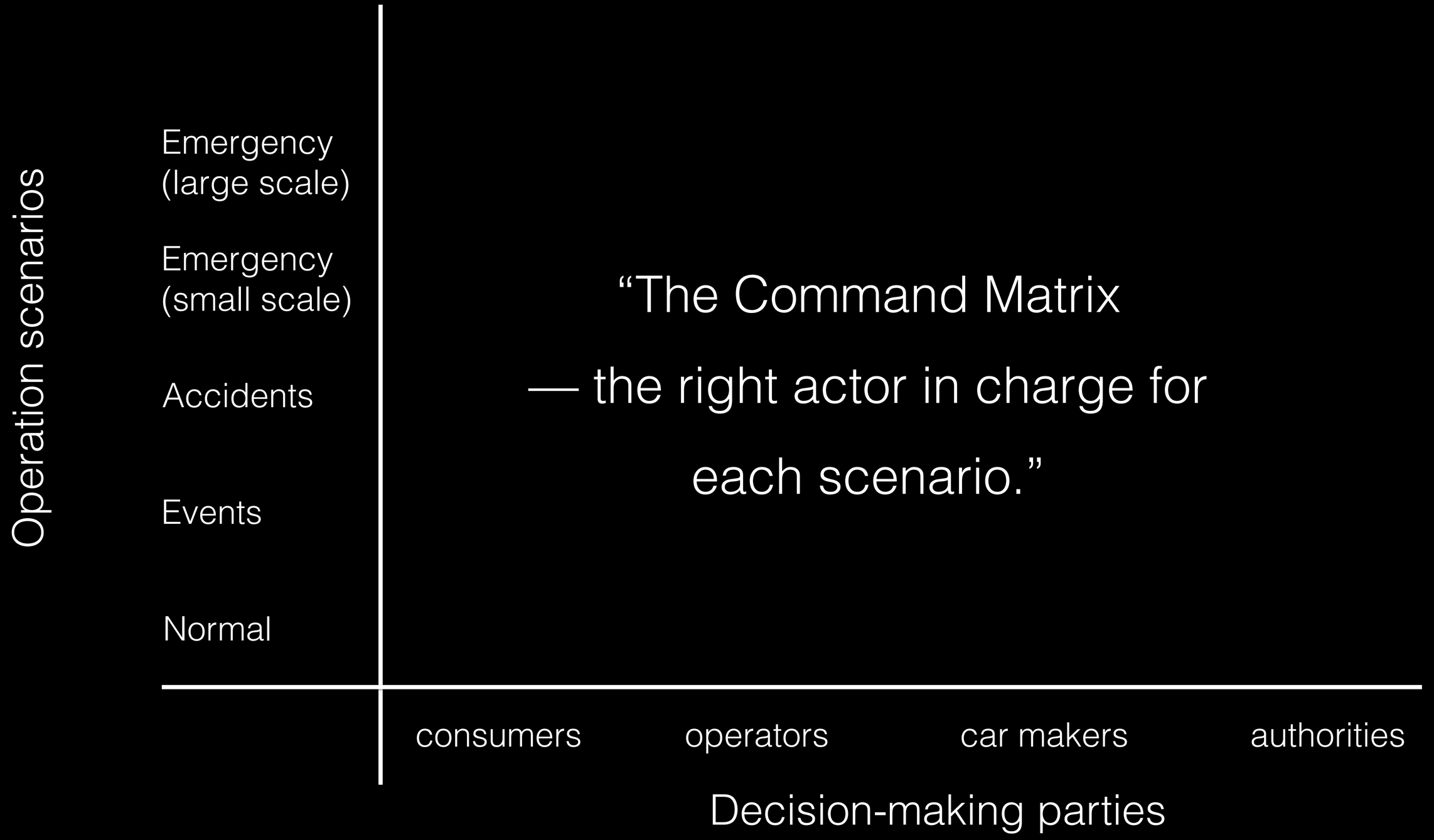
# When we have 100% control,

1. Dynamice bus lane
2. Precise pickup dropoff
3. Dynamic parking
4. Speed limit vs. speed variation
5. AV as traffic controller

6. Congestion pricing —> direct routing
   - Routing to reduce congestion
   - Routing to reduce CO2 emission
   - Routing to reduce crashes
   - Routing to maximize profit

# 3. AV and Human Agency


Levels of decision making
High level:
single vs. pooling;
destination choice;
ownership choice
Mid level:
route choice;
departure time
choice
Low level:
Acceleration,
deceleration,
change lanes
“The Agency Frontier
— where human preference and
machine intelligence meet.”
Fully human
A variety of middle points
Fully machine
Spectrum of human vs machine decision making




"The Command Matrix
— the right actor in charge for each scenario."

# 4. States write the Law

# Cities bear the consequences

Deja Vu of Disruption

Uber and SF battle 10 years ago

Waymo much friendlier

# Two Compelling yet Conflicting Principles

**States' Arguments**

Streamlined

Scalable

Uniform

**Cities' Arguments**

Context Matters

Consequences Are Local

- Livability
- Congestion
- Public transit
- Local enforcement
- Equity goals

# Fear of Preemption Creates a Cycle of Inaction: A self-fulfilling trap

States write the Law

Cities bear the consequences

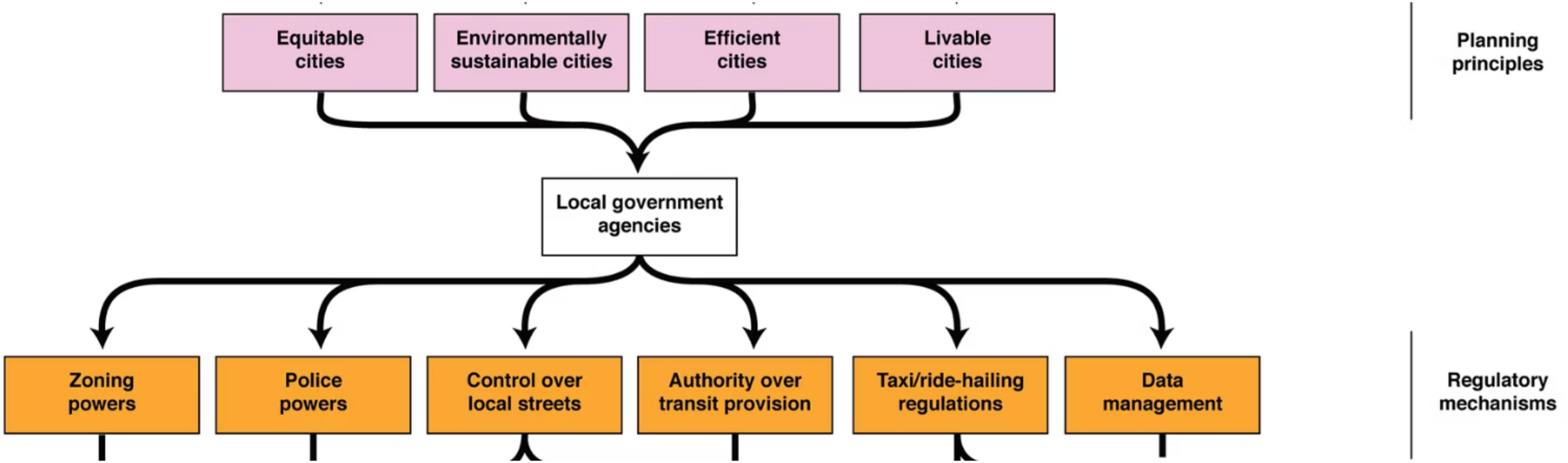
# Three Postures of Cities in AV Deployment

The City as Regulator

The City as Enabler

The City as Co-System Designer

# 5. Are Cities Able to Manage AVs?


Equitable cities
Environmentally sustainable cities
Efficient cities
Livable cities
Planning principles
Local government agencies
Zoning powers
Police powers
Control over local streets
Authority over transit provision
Taxi/ride-hailing regulations
Data management
Regulatory mechanisms

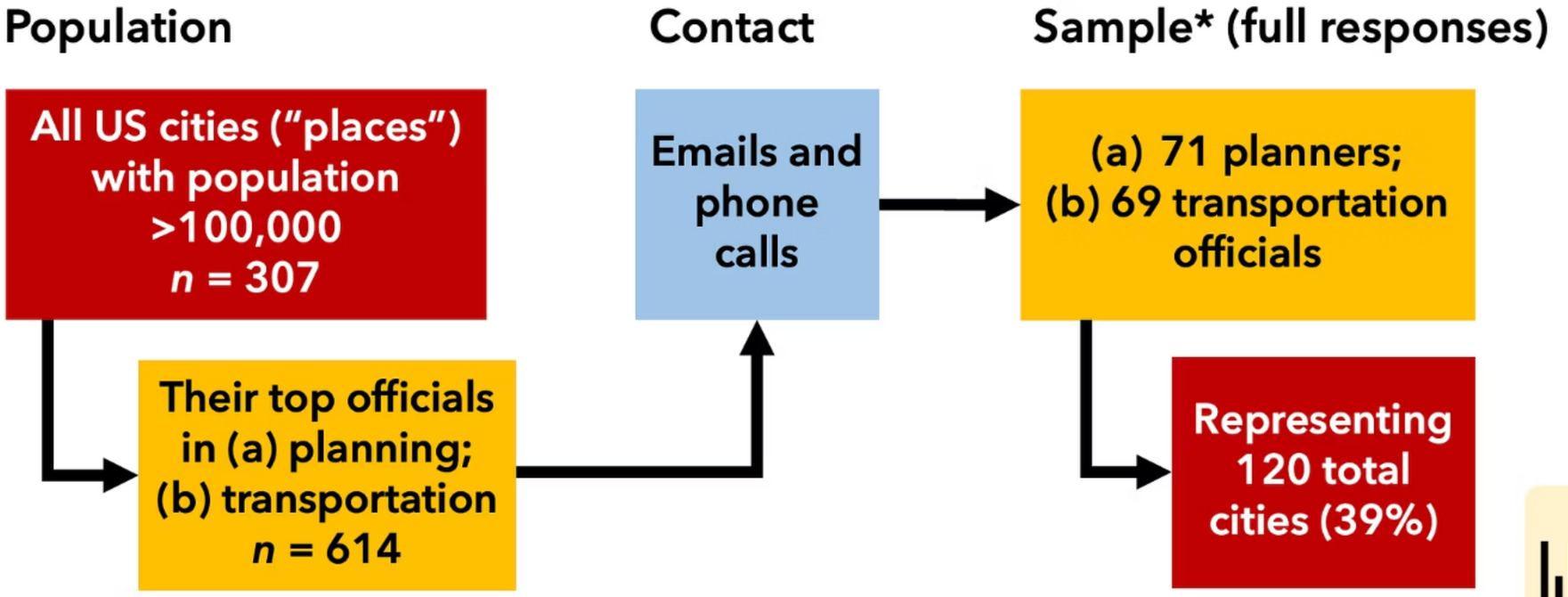

Equitable cities
Efficient cities
Environmentally sustainable cities
Livable cities
1. Lowered parking provision
2. Rethinking of the use of street space
3. Integrated AV and transit system
4. Data clearinghouse
5. Minimum levels of service provision
6. Income-based subsidies
7. Distance and congestion-based road pricing
8. Zero-emission vehicles
Encouragement of sprawling land uses
Disincentive to walk and bike
Less political support for transit, thus lower access
Lower public revenues under current law
Inequitable access to expanded mobility options
Increase in segregation
Increased energy use
Increases in overall distances traveled and auto fleet size

**Policies for Autonomy: How American Cities Envision Regulating Automated Vehicles**

by Yonah Freemark [1], Anne Hudson [2] and Jinhua Zhao [2,*]

# Methods

Survey of a representative sample of officials in large American cities.




* No significant difference ($p < 0.05$) on covariates between sample and population.

# Cities being surveyed

For each policy, please assess

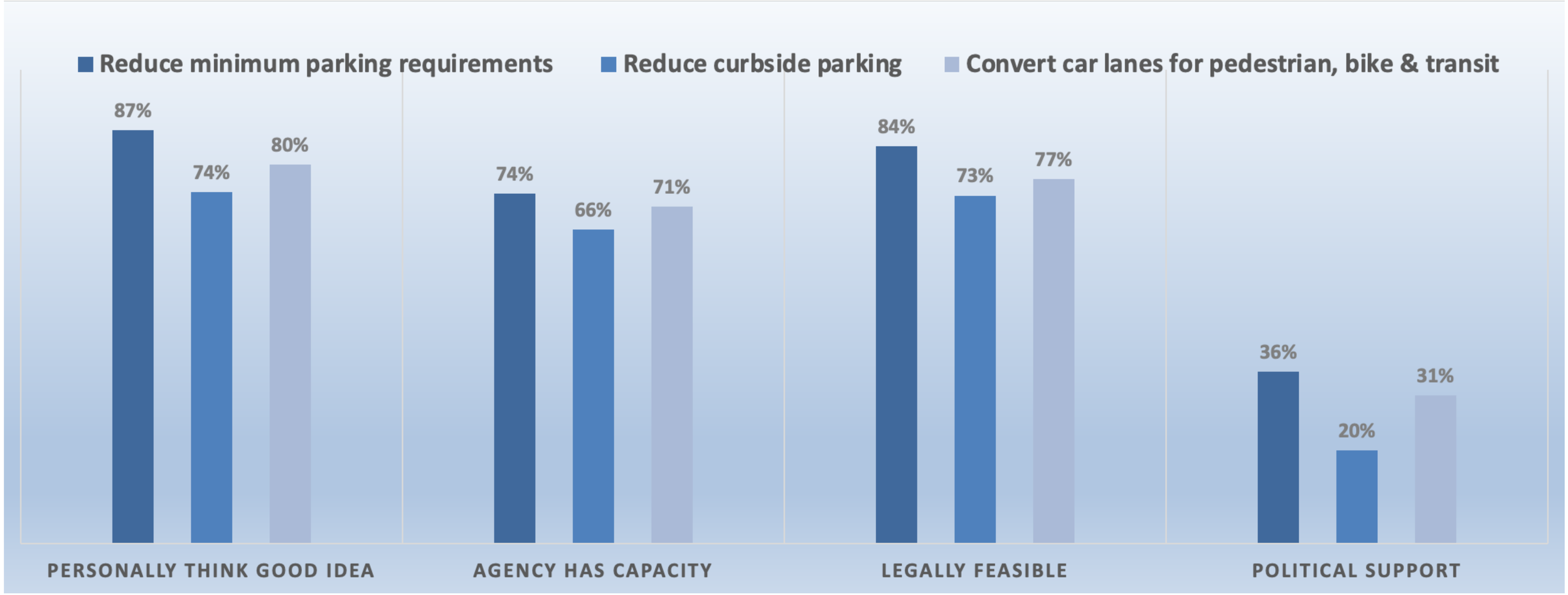
A. Personal support

B. Bureaucratic capacity

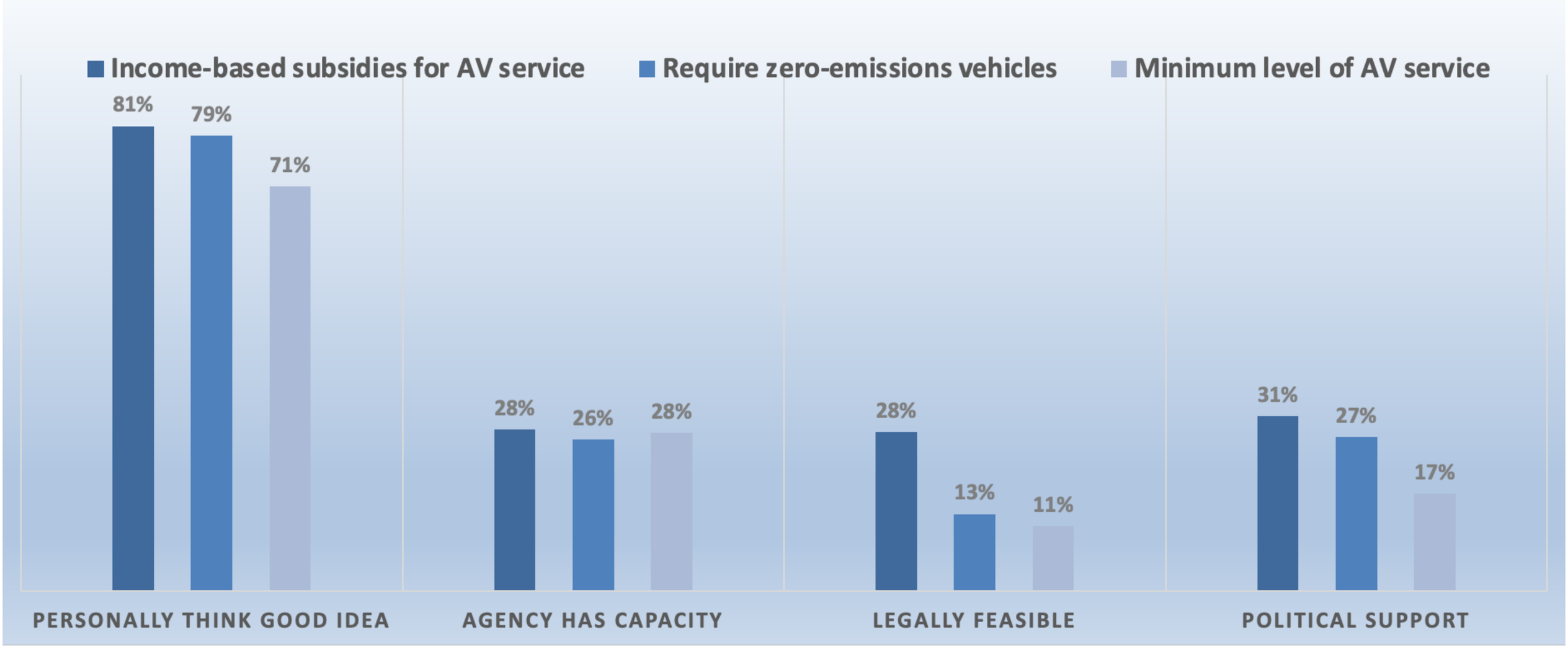
C. Legal carriers

D. Political capital

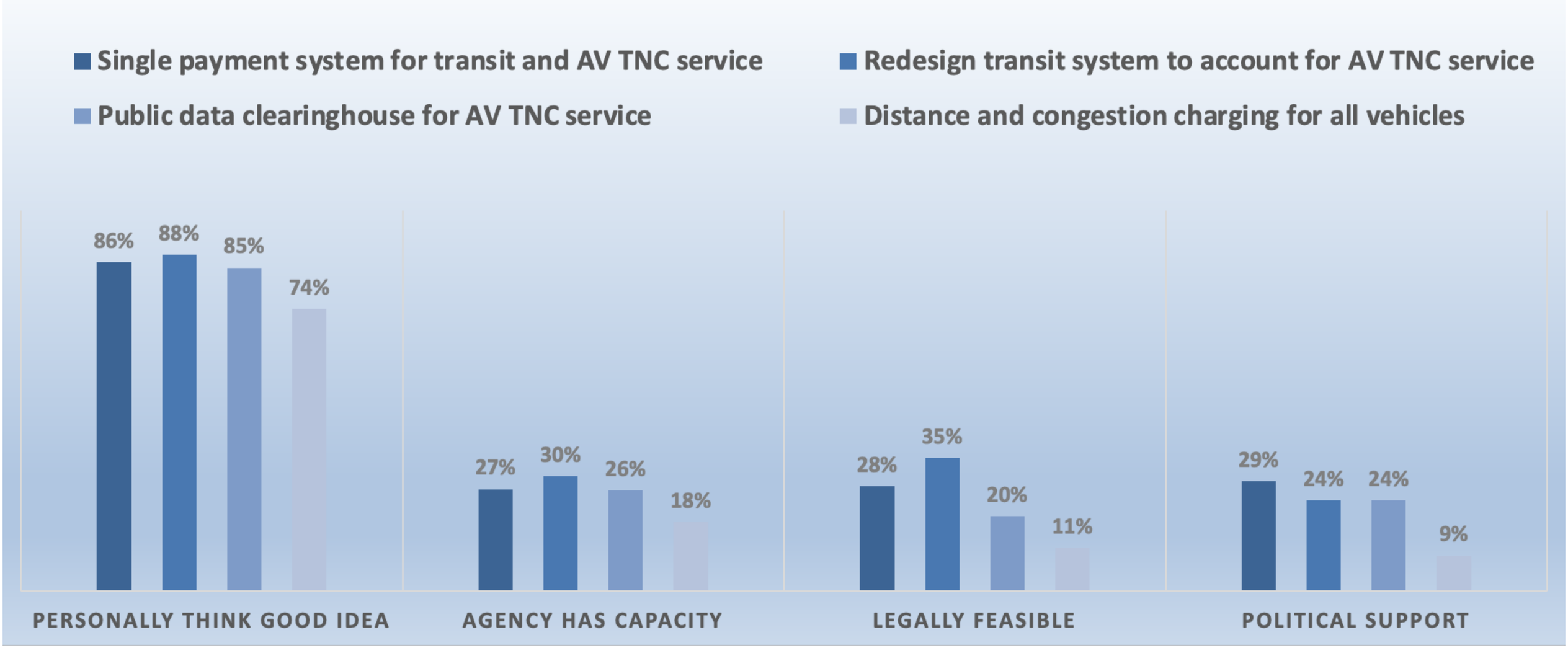
# **Land Use** and the Public **Right of Way**



# **Equity** and the **Environment**



# **Integrated** Mobility Systems



# 5. AVs as an Excuse for Policy Change

# AVs as an Excuse for Policy Change

## Congestion Pricing

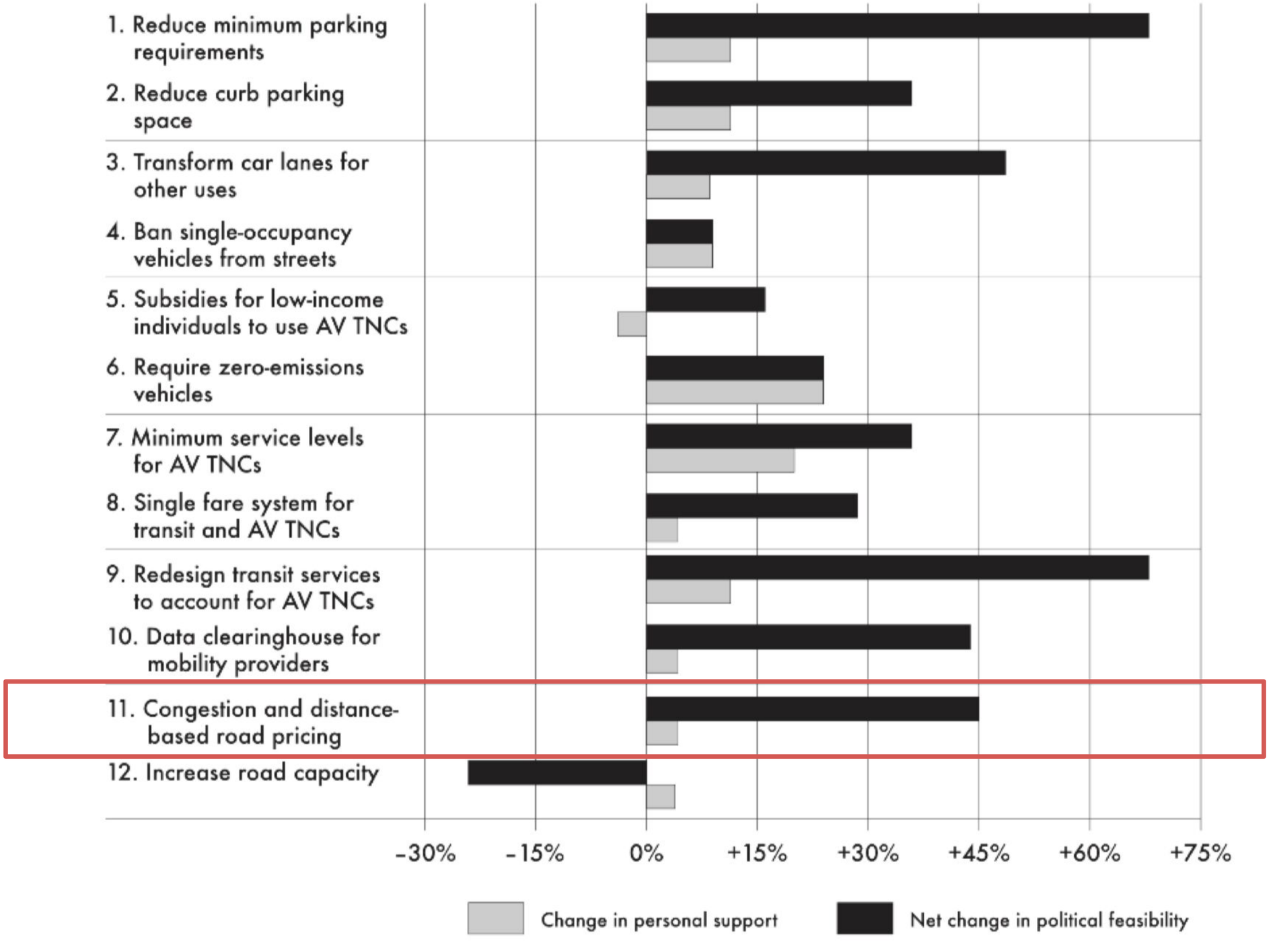
AVs could provide political opportunity to introduce road pricing that was previously difficult.

## Space Reallocation

Technological disruption creates opportunity to replace car lanes with space for other modes.

## Transit Integration

AV introduction allows reimagining transit networks and first/last-mile connections.


1. Reduce minimum parking requirements
2. Reduce curb parking space
3. Transform car lanes for other uses
4. Ban single-occupancy vehicles from streets
5. Subsidies for low-income individuals to use AV TNCs
6. Require zero-emissions vehicles
7. Minimum service levels for AV TNCs
8. Single fare system for transit and AV TNCs
9. Redesign transit services to account for AV TNCs
10. Data clearinghouse for mobility providers
11. Congestion and distance-based road pricing
12. Increase road capacity
–30%
–15%
0%
+15%
+30%
+45%
+60%
+75%
Change in personal support
Net change in political feasibility

# 6. AV and Public Transit Integration

April 3, 2014

# Will a World of Driverless Cars Be Heaven or Hell?

The answer depends in large part on whether we own autonomous vehicles or share them.


*Shutterstock*

By Robin Chase

April 3, 2014 at 7:00 AM EDT

Copy Link

Marginal cost of driving:

Gas, parking, tolls
AND DRIVER'S TIME!

With a personal eAV, it will feel free:

- $0.03 to $0.10 per mile
- $0.05 to $0.16 per km

With a shared eAV, we will experience the "Full" costs (depreciation, insurance, maintenance etc – still no social costs)

Rise of eAVs give us the opportunity to address the dominant policy & infrastructure failings driven by private ICE vehicle.

- Ownership (transforming cost & parking requirements)
- Road congestion (fewer lanes needed)
- Curb congestion (less parking spaces required)
- Vehicle weight/footprint
- Occupancy (??)
- **Regulation**

# REGULATIONS, permits, policies, and fees ARE BUILT ON PAST vehicle typologies

What are reasons to regulate?

- Safety (Speed & Weight)
- Efficient use of assets/resources
- Market failures
- Government incentives

# My Utopic User-Fee Dream

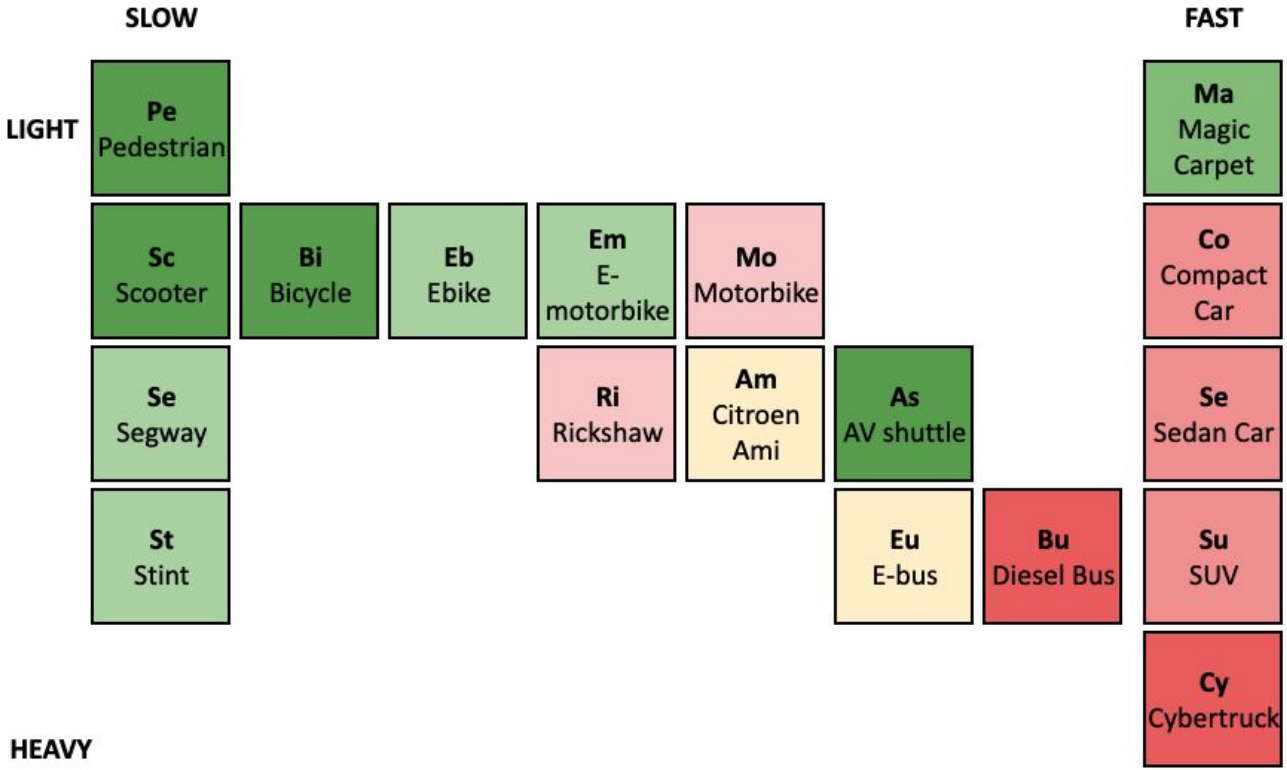
When you get a vehicle, you will know its per mile/distance user fee based on. Everyone and every vehicle pays, no exceptions*:

- Weight
- Footprint
- Emissions
- Congestion price (added when appropriate)

*You are human and get one square yard/meter and 100 kgs free!

I.e. bikes free, full buses heavily discounted

# Good, let's make easy





**Negative, let's make costly/hard**

We can recover the **Human Right to Free Movement**
Improving access for all

1905-1910


2025

# More family-friendly streets

& change incentives for vehicle choice (right-size owned vehicles)

HEAVEN VS HELL VIDEO
https://www.youtube.com/watch?v=DeUE4kHRpEk

# Tag Cloud question:

In one or two words, tell us reasons you use your cellphone camera: